Series 1927 Number 29

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey

of

Crawford County, Michigan

By

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Bureau of Chemistry and Soils

In cooperation with the Michigan Agricultural Experiment Station
and the Michigan Department of Conservation

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SOIL SURVEY OF CRAWFORD COUNTY, MICHIGAN

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COUNTY SURVEYED

Crawford County is in the central-northern part of the southern peninsula of Michigan. (Fig. 1.) It lies inland about 45 miles from Lake Huron and about 65 miles from Lake Michigan. Grayling, the county seat, is 200 miles northwest of Detroit. The county comprises 561 square miles, or 359,040 acres.

FIGURE 1.—Sketch map showing location of Crawford County, Mich.

Physiographically the county is a part of the northern upland division of the southern peninsula of Michigan, which is a part of the great glaciated plain of the Great Lakes region. Most of the land in the county is nearly level or but gently rolling. Local differences in elevation are slight, in few places exceeding 100 feet, although the hills and plateaulike ridges appear to rise boldly above the adjacent sand plains when viewed from a distance. Slopes of the hilly land are either long and expansive, or, where the relief is at all choppy, smooth and rounded. There are no precipitous slopes except the banks of streams, and no rough broken land due to erosion.

The northern part of the county consists of three broad plateaulike masses of high land, having a general north-south direction, three complementary broad sandy valleys, and a wide sandy plain on the east. The central part, from the eastern to the western boundaries, is a wide level sand plain through which Au Sable River and its branches have cut narrow shallow trenches. The southern part of the county is characterized by several detached swells or ridges, irregular in outline but having a general east-west trend. Here, the general relief is gently rolling or moderately hilly. Level sand plains and swamps intervene between the masses of higher land.

The land surface of the county is constructional and probably remains very much as it was left at the close of the last period of glaciation. The more level areas are parts of outwash plains, and the hills are land-laid moraines. Swamps occur both on the level plains and among the hills but are not so extensive in the aggregate as in most other counties in the State. Lakes are not numerous, and only one lying wholly within the county is of notable size. There are comparatively few streams because of the newness of the land surface and the large areas of level land underlain by pervious sand and gravel. The direction of stream flow is somewhat

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irregular or anomalous as the stream courses are determined by constructional valleys left by the ice sheet.

Dry sand plains are estimated as comprising 50 per cent of the total area of the county; hilly or rolling lands, 40 per cent; swamp, 9 per cent; and water surface, 1 per cent.

The general elevation of the county ranges from 1,150 to 1,300 feet above sea level; small areas in the northwestern and southwestern parts lie between 1,300 and 1,400 feet; the maximum elevation is 1,480 feet, and the lowest established elevation on Au Sable River at the eastern county line is about 1,006 feet.[1]

The entire land area of the county, at the time of its first occupation by white men, was covered by a dense forest except for an inconsequential acreage of bog or marsh and some open land on the drier sand plains. Lumbering of pine on a large scale began between 1875 and 1880 and of hardwoods about 1900. At the present time (1928) the original forest, with the exception of a few small tracts of virgin hardwood in the northwestern part of the county, has been cut over by lumbermen. Several types of forest or tree associations were represented in the virgin forest as follows: (1) The hardwood forest in which sugar maple (*Acer saccharum*), beech, yellow birch, and hemlock were the dominant species, and elm, basswood, and white pine were subordinate species; (2) the mixed deciduous-coniferous forest, in which such species as elm, ash, red maple, aspen, and yellow birch were intimately associated with white pine, hemlock, spruce, and fir; (3) the pine forests, in which white pine and red (Norway) pine, or red and jack pine predominated; and (4) the peat and muck swamp forests, in which the dominant species were arborvitae, spruce, balsam fir (*Abies balsamea*), and tamarack. Much of the original forest land presents a desolation of charred tree stumps and trunks, together with a dense growth of brush, briers, and grass; or has grown up to aspen, oaks, and red maple, with very little natural reproduction of the original dominant species. In places in the swamps the forest remains intact, but most of this land has also been partly logged over and in places desolated by fires. Some of the dry sandy plains land supports a scattered growth of jack pine, low blueberries (mainly species of Vaccinium), sweetfern (*Comptonia asplenifolia*), and bracken, together with various grasses, the most common of which are Canada bluegrass (*Poa compressa*), oatgrass, locally called "buffalo" grass (*Danthonia* sp.) and little bluestem (*Andropogon scoparius*). The bogs are covered with a dense growth of heath shrubs such as blueberries, leatherleaf, and Labrador-tea (*Ledum* sp.), with some scattered black spruce and tamarack, and in places the marsh growth consists of various sedges and bluejoint (*Calamagrostis canadensis*).

It is estimated that about 11 per cent of the cut-over forest land has been cleared of trees and stumps and was at one time used for farming purposes, but a considerable part of this land has been abandoned, and at present only about 2 per cent of the total land area of the county is actually under cultivation.

An abundant supply of healthful water can be obtained from shallow wells less than 100 feet deep throughout the greater part of the county, and flowing artesian wells are found in a few places.

[1] Elevation determined by C. O. Wisler, Michigan Department of Conservation, Land Economic Survey.

Streams are perennial in flow and carry clear water. Only a few springs occur and these are of little consequence as sources of water supply.

The population of Crawford County was 4,049 in 1920, but according to the preliminary census figures for 1930, it has decreased since that time.[2] The population of Grayling, the county seat, was estimated at 2,500 in 1928. Frederic, in the northern part of the county, is the only other large town. The population of the county reached its maximum between 1890 and 1910, at the time of the peak of lumber production and the peak of agricultural settlement.

Lumbering has greatly declined and, although still carried on, is comparatively unimportant, only a few large lumber mills remaining at Grayling. Agriculture has replaced lumbering only to a very small extent, and no manufacturing industries have been established. The attractiveness of the country for hunting and fishing and for summer cottages and camps on the lakes and streams is a very considerable commercial asset which brings in a large transient population during the summer and fall. The total value of all farm crops and livestock products amounted to $89,939 in 1924, according to the United States census.

The Michigan Central Railroad passes through the county and provides good transportation to the cities and markets of the southern part of the State. State trunk-line highways provide facilities for automobile traffic. The main roads are passable throughout the year except at times during the winter when they are filled with snow. The more remote parts of the county can be reached only by unimproved sand roads, but no part is entirely inaccessible.

CLIMATE

The main features of the climate of Crawford County are an average precipitation of about 30 inches annually (including melted snow), an average annual snowfall of 78 inches, a mean annual temperature of about 42° F., rigorous winters, short mild summers, fairly high humidity, a large number of cloudy days, small percentage of possible sunshine, and low evaporation of moisture.

The precipitation is fairly well distributed throughout the year. The rainfall occurs mostly as slow and prolonged rains or as frequent showers but rarely as destructive downpours. The amount is ample ordinarily for the production of the staple crops grown in the region, except on the more pervious and nonretentive sand soils, as the evaporation is comparatively low and extended periods of drought are rare. Hailstorms are of very rare occurrence.

The snowfall is heaviest from November to March, but light falls and flurries may occur as late as May and as early as September. A blanket of snow, which affords protection to fall-sown grain, may be depended on during the winter.

The temperature records show extremes higher in summer and lower in winter than in coastal counties of the southern peninsula. There is a range of 142° from the minimum recorded in winter to the maximum in summer, but these extremes probably have very little direct influence either on health or on agriculture as they are

[2] Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

infrequent and of short duration. The average frost-free season, as shown by the average dates of the last killing frost, May 27, and the first, September 15, is 110 days. It should be understood, however, that hay, small grain, and some native plants may start and continue growth before and after the dates of killing frosts as given by the Weather Bureau. Killing frosts have been recorded in every month of the year. Corn does not always reach maturity as the growing season is short and the cool nights are unfavorable to its growth, but by the selection of hardy and early-maturing varieties grain may be produced, and the crop always yields some forage or silage. In the swales or low places and in wetter situations, all crops are susceptible to damage from late spring freezes and both summer and autumn frosts. Occasional losses in handling potatoes, one of the chief cash crops, may be expected because of very cold weather in October, but ordinarily there is sufficient time to harvest this and all other crops grown before extremely cold weather and heavy snows set in.

The maximum number of cloudy days occurs in the winter and spring. The summer season is characterized by a large number of clear days and a fairly high percentage of the possible sunshine.

The only climatic data for the county are compiled from records of the United States Weather Bureau at Grayling in the central part of the county and, with slight exceptions, are representative of climatic conditions in the county. These observations cover a period of about 30 years and are given in Table 1.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Grayling, Mich.*

[Elevation, 1,175 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1909)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	22.5	55	−33	2.16	1.60	3.86	17.1
January	16.7	52	−35	2.08	1.60	1.45	17.2
February	15.2	55	−41	1.87	1.20	3.00	15.2
Winter	18.1	55	−41	6.11	4.40	8.31	49.5
March	25.6	74	−35	1.88	1.10	1.60	8.6
April	41.3	87	− 6	2.21	1.17	8.00	5.4
May	53.4	98	10	3.01	3.45	4.15	.8
Spring	40.1	98	−35	7.10	5.72	13.75	14.8
June	63.4	100	27	2.69	2.13	3.00	.0
July	67.3	101	28	3.03	1.65	6.80	.0
August	64.1	97	29	2.92	.53	2.90	.0
Summer	64.9	101	27	8.64	4.31	12.70	.0
September	57.8	94	19	2.95	2.75	3.00	.1
October	46.8	87	7	2.75	1.60	.82	2.4
November	34.0	74	− 6	2.86	1.50	3.30	11.1
Fall	46.2	94	− 6	8.56	5.85	7.12	13.6
Year	42.3	101	−41	30.41	20.28	41.88	77.9

AGRICULTURE

The history of the settlement of the county and of the agriculture are closely connected with lumbering, which began on a large scale in the decade 1870–1880. The first land to be logged over was that covered by pine forests, and most of these trees were removed by 1890. The lumbering of hardwoods and swamp timber followed but was of less importance because of the comparatively small areas. The farming population did not increase so rapidly as in counties which had a greater proportion of hardwood timber. The early population, excluding trappers, came primarily to operate the logging camps and lumber mills, and only a small amount of farming was carried on. The census of 1880 and that of 1890 show, respectively, 175 and 202 farms in the county, but the amount of land actually in cultivation probably did not exceed 3,000 acres. A small income was realized by the farmers through supplying the camps and mills with necessary agricultural products, particularly hay and other feed for work animals. At the same time the farmer could work in the logging camps in the winter and thus add to his income. Probably the greater number of the earlier-established farms have been abandoned, particularly those on the more sandy lands.

The total population residing permanently in the county has at no time exceeded 5,000, and only a small proportion has been wholly engaged in, or dependent on, agriculture. At present (1927) the agricultural population is about stationary or is probably decreasing. Only about 11 per cent of the total area of the county is in farms, and less than 3 per cent of the land is in cultivated crops or cleared for plowing.[3] This practical failure of agricultural development may be accounted for in part by the rapidity with which the forest was exploited and failure to provide for reforestation; in part by the poor quality of most of the pineland for the present general farm crops and methods of farming; and in part by cost of clearing land, distances from outside markets, and absence of local markets, as lumbering has not been replaced to any considerable extent by other industries.

The early farming consisted in the growing of hay, oats, potatoes, and a small amount of wheat and corn, and the raising of some livestock. The tendency during later years has been to devote greater attention to dairying, to seed crops, to poultry farming, and to special products such as can be disposed of locally.

At present the more important crops are hay, corn, oats, potatoes, buckwheat, rye, and wheat. Other crops which are or can be grown with some measure of success are alfalfa, sweetclover, field peas, beans, turnips, rutabagas, red clover as a seed crop, sunflowers, and barley.

Hay and forage crops occupy a greater acreage than any other field crop, and ordinarily the total value is greater than that of any other crop. The hay is principally timothy and red clover or alsike clover, mixed, and considerable timothy alone is grown. Fairly good yields of red clover are obtained on the better sandy loam and loam soils without liming the land, but clover apparently can not be successfully grown on the deeper sands either on the hills or on the

[3] According to estimates made by the Land Economic Survey, 50 per cent of the farms, or farm land, is classified as "abandoned farm land."

plains. The acreage of alfalfa is still very small, but where the best-recognized methods for growing this crop are followed, fair results should be obtained on the better soils such as Coventry loam, Nester loam, and Roselawn sandy loam. Ordinarily, only one cutting a year is obtained, and the yield is from 1½ to 2 tons an acre on these soils. It is perhaps inadvisable to attempt to grow alfalfa on the lighter, drier, and more acid sands, such as the Grayling, Roselawn, and Rubicon, without heavy manuring, liming, and fertilization. The acreage of sweetclover has also increased during the last few years, and this crop can perhaps be successfully grown on much of the hilly sandy land. Other crops grown for forage are corn, rye, oats, barley, and vetch. The forage crops are mainly consumed on the farms where grown.

Corn is grown mainly for forage and silage, and both dent and flint varieties are planted. This crop is susceptible to damage from early frosts, particularly in the lower situations. Rye occupies only a small acreage but it can be grown fairly successfully on the light sandy soils. It is grown for grain, forage, and as a green-manure crop. Oats are fairly successful throughout the county on practically all types of soils, except the lightest and driest sands. Yields ranging from 35 to 40 or more bushels are obtained on the more productive soils. Mixtures of oats and barley, also oats and vetch, are grown. Winter wheat can be grown but the yields are low, because most of the soils are too sandy, and it can hardly be considered a profitable crop. Buckwheat does fairly well on many soils. It is grown as a sale crop and as feed for poultry and livestock on the farms.

Potatoes are a cash crop throughout the county, as they can be grown successfully on the sandy soils. The average yields under present conditions are not high, but the potatoes are of good quality.

Navy or white beans may be grown with a fair degree of success on the better sandy lands. The acreage, however, remains small.

A variety of fruits can be grown throughout the county, but climatic conditions are unfavorable for extensive commercial production. Apples are the principal orchard fruit. Pears, grapes, plums, strawberries, raspberries, and gooseberries are grown for home use or for sale on the local market.

The total value of all livestock according to the census of 1924 amounted to $75,424. The principal source of income is from dairy cattle and dairy products, but a few beef cattle, sheep, and hogs are kept on some farms. Extensive feeding or raising of livestock on ranches has not proved successful. Poultry and eggs are an important supplementary source of income on most farms.

Liming of the land is not common practice. Apparently lime is not important for potatoes, and on most of the soil that is under cultivation at present little difficulty has been experienced in obtaining good stands of red clover without lime. Although liming would very probably be beneficial on all the cultivable land, on the more acid sands, such as Grayling, Rubicon, and Roselawn, it is regarded as essential for legumes. Barnyard manure, where available, is generally used, and green-manure crops, such as rye, are grown for maintaining the productiveness of the soil.

Commercial fertilizers can probably be succesfully utilized for increasing yields, especially of potatoes. Experimental tests at the

Michigan Agricultural Experiment Station farm at Grayling indicate that small grains, sweetclover, and alfalfa will also respond to commercial fertilizers, and their use in conjunction with liming and manuring is advised.[4]

Rotation of crops is observed, although no definite plan is generally followed. On most farms it is perhaps the most common practice to follow small grain with red clover, and clover with potatoes or corn. Alfalfa and sweetclover are usually followed by potatoes or corn.

The character of the soil has exerted a striking influence on the distribution of the farming population, notwithstanding that it is very small. There are four separate farming communities in the county, all located on the naturally most-productive soils. The greater number of farms and those having the highest assessed valuation are located on the loam soils or soils underlain directly by sandy clay, such as Coventry loam, Nester loam, Roselawn sandy loam, and Ogemaw sandy loam. Dry level sand soils and rolling or hilly sand soils, such as Grayling sand and Roselawn sand, are either unused for any purpose or are very sparsely occupied and show the greatest number of abandoned farms and fields. The heavier soils are best suited to dairying and general or diversified farming, as the greater part of the timothy, clover, corn, oats, wheat, and field peas produced are grown on this kind of land. It is recognized that rye can be grown with greater success than wheat, barley, and oats, and that timothy is more successful than red clover on the lighter sandy soils. Potatoes can be more successfully grown on hilly or sloping light sandy loam soils, such as Roselawn sandy loam, than on the wet sands, mucks, and peats, or on the dry sands of the pine plains.

According to the preliminary farm census figures for 1930 only about 10 per cent of the land in the county is in farms and about 20 per cent of the farm land is in crop land and plowable pasture, that is, actually improved for agricultural purposes. The small individual holdings are for the most part in 40, 80, and 160 acre tracts. Lots and small subdivisions are laid out around the lakes and along Au Sable River. The remaining virgin forest and the wild cut-over land is for the most part still held in large tracts by the lumber companies, by hunting and fishing clubs, and by land companies for speculative purposes. The State owns or controls 74,845 acres[5] which is largely in forest reserves, and in addition a large tract is included in a State military reservation.

As such a large proportion of the total acreage of the county is uncultivated or is idle and unused land, some sort of classification is necessary in order to determine the value and possible utilization of the land for some productive purpose. The classification here given is based primarily on the soil type, as the soil type implies not only the physical and chemical character of the soil but in addition more or less uniformity in relief, drainage, and natural vegetation. Future economic conditions can not enter into a classification because they are not known, nor can possible discoveries in agricultural science be taken into account. Changes in either

[4] McCool, M. M., and Weidemann, A. G. The soils of Michigan—Grayling sand. Mich. Agr. Expt. Sta. Spec. Bul. 180, 24 p., illus. 1929.
[5] Figures compiled by Michigan Department of Conservation, January, 1929.

must obviously affect the value of the land and its agricultural possibilities.

It is apparent under present economic conditions that a very large acreage of land in Crawford County is of little agricultural value and is not being utilized other than for the meager grazing it provides or for resort and recreational purposes. Some of this nonfarming land, however, may be utilized for the growing of timber by the State or National Government, at least until there is some real social or economic need for the land for homes and farms. Practically all the old cut-over land suitable for farming under existing conditions is occupied, so that there appears to be little probability of an increase in agriculture from new land, except possibly a small acreage in the northwestern township of the county which is now in virgin hardwood forest or recently cut over.

A broad agricultural classification showing the present (1927) agricultural condition and the extent of occupation of the land in Crawford County, is set forth in Table 2. It must be remembered, however, in the land classification here shown, that the classes of land are relative only as applied to this county. First-class land here may not be comparable to first-class land in other parts of the United States, or even to first-class land in other parts of Michigan.

TABLE 2.—*Agricultural classification of land in Crawford County, Mich.*

Soil types	Approximate acreage	Class and description	Present condition and extent of occupation
Greater parts of Coventry loam and Nester loam; very small acreage of Roselawn sandy loam.	4,000	A—Moderately fertile productive and durable soils; stone free or not excessively stony; not excessively hilly for general farming; retentive clayey subsurface layer, first-class or fair pasture where cleared of brush and second-growth trees.	Greater part in small farms; farming not highly prosperous but comparatively successful; estimated that from 60 to 75 per cent is cultivated land; remainder in second-growth hardwood forest or stump pasture.
Greater parts of Roselawn sandy loam, Ogemaw sandy loam, Bergland loam, Bergland clay loam, Kalkaska sandy loam, Blue Lake loamy sand, and Roselawn gravelly sandy loam.	22,000	B—Low or medium natural fertility; deep clayey subsurface layer, in part wet, in part dry, and well drained; moderately hilly and sloping to flat; not excessively stony; reclamation possible within practicable cost; pasture value from fair to good; marginal farming and farms which provide homes, but only a part of the income for family living.	Estimated that less than 10 per cent has been cleared and placed under cultivation; limited use for potatoes, grain, and hay crops; wild land mainly in pine stumps with second-growth aspen, oaks, and other hardwoods; in part in virgin hardwood and recent slash; swamp land thickly set with stumps or culled-over swamp hardwoods, and fir, cedar, and spruce.
Greater parts of Roselawn sand, Grayling sand, Rubicon sand, Hartwick sand, Saugatuck sand, Newton loamy sand, Bridgman fine sand, Griffin sandy loam, peats, and mucks.	333,000	C—Low or medium fertility; very dry or excessively wet and swampy; land lowest in assessed valuation, and either submarginal for farming or nonagricultural land under present conditions.	Estimated that less than 1 per cent is in cultivation. Large percentage of farms abandoned. Part in State forest reserve, military reservation, or State-owned scattered tracts. Except parts of swamps all is cut-over land and pine stumps remain; poor or fair oaks, aspen, and pines on dry sands; peats mostly densely covered with tree and shrub vegetation.

All of the land not occupied by virgin forest, or having special value for the tourist and resort business, is comparatively low priced at the present time (1927). The average assessed valuation of land in farms is $11.70 and of wild or cut-over land is $4.70 an acre.[6] The

[6] DEVRIES, W. CORRELATION OF PHYSICAL AND ECONOMIC FACTORS AS SHOWN BY MICHIGAN LAND ECONOMIC SURVEY DATA. Jour. Land and Pub. Utility Econ. 4: 295–300. 1928.

assessed value of unused cut-over land, such as is embraced in Grayling, Rubicon, Saugatuck, and Roselawn sands, may be as low as $2.50 an acre. The best farm land is assessed at approximately $18 an acre.

SOILS

The soils of Crawford County comprise a large number of distinct types but do not, however, show quite so wide a range and diversity in texture, structure, chemical composition, fertility, and moisture content as soils in most of the other counties of the State. Although they show in places that lack of uniformity and textural and other variations within very short horizontal distances, which is common to Michigan soils, very large bodies of soil are comparatively uniform.

The surface layers, exclusive of forest litter and humous soil, range in texture from loose incoherent nearly pure sand to silty loam and clay loam. The greater part of the mineral soils are sands and light sandy loams to depths of 3 feet or more. The sands comprise 84.5 per cent of the total area of the county and the sandy loams 4.9 per cent, whereas those soils which would have a loam, silt loam, or clay loam texture in the plow soil if cultivated, comprise only about 1.6 per cent. The greater part of the land, exclusive of swamp, is arable. It is estimated that less than 5 per cent is nonarable or difficult to manage because of the extreme stickiness and toughness of the clay, extreme stoniness, susceptibility to blowing, and excessively rough relief and steep slopes. About 9 per cent consists of muck and peat, which have their own peculiar tilth characteristics and problems of management, but in Crawford County have practically no value for cultivated crops at present.

The content of organic matter in the plow layer of the greater part of the soils is, or would be if cultivated, comparatively low. The forest mold layer of the well-drained virgin soils is, or was originally, nearly everywhere thin, not exceeding 2 or 3 inches, and in some soils is so thin as to be scarcely measurable. Some of this is lost in clearing the land and what remains is not durable under cultivation, especially in the sands. The soils are penetrable to a great depth as the underlying material is unconsolidated glacial drift.

Probably 98 per cent of the soils are acid in reaction in the natural surface horizons of mineral soil or in the plow layer. It is estimated that about 85 per cent of the soils are acid to a depth ranging from 36 to 40 or more inches; from 10 to 15 per cent are strongly acid in the surface soil but contain sufficient calcium and magnesium carbonates, or sufficient limestone gravel, at a depth ranging from 24 to 36 inches to give an alkaline reaction; and that less than 2 per cent are not acid in the surface layers under natural conditions. The organic soils are nearly everywhere medium or strongly acid and are mainly peats, with scarcely any of the well-decomposed so-called "high-lime" mucks common in the southern part of the State.

Most of the soils are naturally fairly well drained as the water table is not high and the slope is sufficient to provide free run-off. It is estimated that 13 per cent of the area of the county is characterized either by a high water table or by a permanently swampy condition.

The fertility and productivity of the soils, according to the standards for Michigan, are in general medium to low. Although analyses of the dominant soil types in this county do not show evidence of abnormally small amounts of the mineral constituents ordinarily determined, much of the soil is poor because of a combination of low or only medium content of plant nutrients and a deficiency of moisture, as in the pine-plain sands. A considerable proportion of the land is poor because of a low content of mineral plant food and excessive water, as in some of the peats and swamp-border mineral soils such as the Saugatuck and Newton.

For purposes of mapping and correlation, soils are grouped in series on the basis of common characteristics of color, consistence, texture, chemical composition, and thickness of the whole soil and of the separate horizons of the soil profile. A soil series is divided into soil types, the unit of mapping, on the basis of texture of the surface soil, or plow layer, of mineral soils, or on the basis of some other single distinguishing specific difference within the series group. Each soil series is given a name for convenience of reference and description, and each soil type is further distinguished by an additional texture class name.

In interpreting or drawing conclusions from the soil map it should be understood that soil types are rarely sharply separated but rather grade into each other, therefore mathematically accurate lines of demarcation are not to be expected. Many small inclusions of other soils occur and there may be slight variations in each soil area shown, so that each soil color on the map must be understood to represent a dominant soil condition and not a single type of soil strictly uniform in every respect. The amount of detail which can be shown is, of course, limited by the scale of the map. The scale here employed is 1 inch to the mile and on this scale it is not generally practical to attempt to locate accurately separate bodies of soil which are less than 5 acres in extent.

The acreage and proportionate extent of the different soils mapped in Crawford County are given in Table 3; their location and distribution in the county are shown on the accompanying soil map; and a description of the individual soil types in their relation to agriculture is given in subsequent pages of this report.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in Crawford County, Mich.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Coventry loam	4,288	1.2	Saugatuck sand	5,952	1.6
Nester loam	128	.1	Ottawa loamy sand	2,240	.6
Roselawn sandy loam	7,232	2.0	Bridgman fine sand	768	.2
Roselawn gravelly sandy loam	5,056	1.4	Bergland clay loam	192	.1
Roselawn sand	34,048	27.1	Bergland loam	768	.2
Gravelly phase	63,296		Newton loamy sand	6,784	1.9
Kalkaska loamy sand	7,616	3.1	Griffin sandy loam	320	.1
Gravelly phase	3,776		Rifle peat	25,984	7.2
Kalkaska sandy loam	3,904	1.1	Lupton muck	1,216	.3
Blue Lake loamy sand	3,904	1.1	Greenwood peat	2,816	.8
Hartwick sand	11,776	3.3	Kerston muck	896	.2
Grayling sand	72,448	31.4	Houghton muck	1,728	.5
Gravelly phase	40,192				
Grayling coarse sand	12,544	3.5	Total	359,040	
Ogemaw sandy loam	960	.3			
Rubicon sand	23,936	10.7			
Gravelly phase	14,272				

COVENTRY LOAM

Coventry loam comprises the soil of the high-lying level hardwood lands in the northwestern part of the county and is characterized by a comparatively thin layer of loam or silt loam and clay overlying loose sand, gravel, and cobbles.

Under a forest cover, or in the virgin state, the surface soil typically consists of a surface layer of forest mold and humus 2 or 3 inches thick, underlain by an ash-gray loam or silt loam layer from 3 to 8 inches thick. This, in turn, is underlain by a pale-yellow or leather-colored friable loam layer from 6 to 15 inches thick, passing into a yellow or pale reddish-yellow friable layer of sand, gravel, and clay, which rests on unconsolidated coarse gravelly or bowldery sandy drift containing a small amount of limestone and shale, of gravel and stone size, at a depth ranging from 2 to 5 feet.

The plow soil is grayish-brown light loam which is not excessively stony, scours readily from the moldboard of the plow, and is easily cultivated. The organic-matter content of cultivated fields is not high but is fair for this region and somewhat higher than that of the well-drained sandy soils. The different layers are medium or strongly acid down to the coarse sand and gravel substratum, or to a depth ranging from 2 to 4 feet. The soil holds a fair amount of moisture without being excessively wet. The fertility is higher than that of the well-drained sands and sandy loams, but there is no evidence of an unusual quantity of essential plant nutrients.

The land is nearly level or is characterized by broad swales and gently undulating areas.

The original forest consisted of a fairly heavy stand of hard maple, beech, yellow birch, elm, basswood, hemlock, and probably a few scattered white pine. A large proportion of the land is cleared and farmed, and most of the remainder is in stump pasture or wood lots consisting of aspen and a second growth of the original hardwood species.

Coventry loam has considerable agricultural value at the present time, but is of small total extent, occupying only 1.2 per cent of the total acreage of the county. The principal bodies are in Maple Forest Township, east of Frederic. The soil is fairly uniform, but small bodies resembling the Kalkaska, Blue Lake, and Hartwick soils are included in mapping.

Crops grown are timothy and clover hay, oats, potatoes, rye, wheat, corn, alfalfa, peas, sweetclover, beans, and buckwheat. Potatoes are the most dependable cash crop at present, as the yields are fair and the quality good. Corn is not dependable for grain. Apples, raspberries, gooseberries, and garden vegetables for home use, and to some extent for local markets, may be grown. Dairying is the most profitable adjunct to general farming.

In the management of the soil it is most essential to maintain or increase the amount of organic matter by the use of green manures or barnyard manure. Commercial fertilizers could be profitably used on some crops, particularly potatoes, and liming might be profitable for alfalfa and sweetclover.

NESTER LOAM

Nester loam comprises the heavier, well-drained hardwood land of the county, locally called clay land. Under a forest cover, or in the virgin state, the surface layer, from 2 to 4 inches thick, consists of a mixture of forest litter, leaf mold, and humous soil. It is underlain by a gray or ash-colored silty and sandy layer from 3 to 6 inches thick. Beneath this is yellow or brown silty clay loam or sandy clay loam, from 3 to 8 inches thick, which is underlain by red or chocolate-brown moderately compact clay loam. This material is plastic when moist and when dry becomes pale red or pale reddish brown and is hard and crumbly. The substratum is clayey drift material, either massive red clay or alternate layers of clay and sand. Under cultivation the surface soil is a mixture of the upper three layers. It is grayish-brown light loam or sandy loam which scours readily from the moldboard and which is free from excessive cloddiness where care has been taken to prevent erosion.

The content of organic matter is not high, but may be considered good for this region and is higher than that of the well-drained sandy soils. The proportionate amounts of clay, silt, and sand within plow depth vary considerably even in the same field, and there is also considerable variation in the depth to the clay layer, but the greater part of the soil is loose in structure and loamy in texture, and a heavy layer is present at a depth ranging from 15 to 24 inches.

Nester loam generally shows slight or medium acidity to a depth ranging from 20 to 36 inches, but below this depth the reaction is alkaline, probably owing chiefly to the presence of carbonate of lime. The soil is fairly retentive of moisture, owing to the clayey character of the subsoil and substratum, but it does not hold excessive quantities of water. Chemical analysis and other evidence show that the natural fertility is good. Nitrogen and phosphorus are likely to be present in smaller quantities than other plant nutrients, but there is no evidence that the quantities of these elements are abnormally small.

Nester loam is inextensive, the total area mapped being only 128 acres. It occurs in several small widely separated areas in the southeastern part of the county.

Areas of this land are level or gently rolling, and in general, the natural drainage is sufficient for successful farming.

The original forest cover consisted mainly of hardwoods, principally hard maple and beech, with smaller numbers of elm, basswood, yellow birch, and white ash. Some hemlock and a few scattered white pine were intermixed with the hardwoods.

On account of the small size of individual areas and their close association with other soils, such as Ottawa loamy sand, Ogemaw sandy loam, and Roselawn sandy loam, few farms are composed entirely of this soil. The land is suited to the production of red clover and timothy hay, corn, oats, wheat, potatoes, navy beans, field peas, barley, rye, sweetclover, buckwheat, alfalfa, and rutabagas. Red clover returns good yields without liming or fertilization and is grown both for hay and as a seed crop. Alfalfa can probably be grown with moderate success. Apples are the principal orchard fruit grown.

The soil is nearly free from large stones and presents no special tillage problems. Commercial fertilizers, if applied, would probably profitably increase the yields of grain, potatoes, and beans. It is most essential to maintain the supply of organic matter through the use of barnyard manure or by turning under green crops.

ROSELAWN SANDY LOAM

Roselawn sandy loam is characterized by a light sandy, loosely coherent surface layer overlying a friable pale-red sand and clay mixture at a depth ranging from 20 to 40 inches. A typical profile of the virgin soil shows the following layers: (1) A layer of loose mold and humous soil, from 1 to 3 inches thick; (2) gray or lavender incoherent loamy sand, from 2 to 6 inches thick; (3) yellow loamy sand or sandy loam with yellowish-brown coloring at the top, from 18 to 30 inches thick; (4) a moderately firm but friable and penetrable red clay and sand mixture; and (5) a substratum of sandy and clayey drift containing only a small proportion of limestone material. The plow soil of cultivated land is variable in color and texture, but in most places is gray or light grayish-brown sandy soil containing sufficient silt, clay, and organic matter to produce a loamy feel and slight coherence. The content of organic matter is low and not very durable under cultivation. The soil is pervious but contains sufficient clay at a slight depth to check slightly the free downward movement of water, and it therefore retains a little more water for plant use and has slightly higher natural fertility than the Grayling and Roselawn sands. The soil is medium or strongly acid in all layers to a depth of 3 or 4 feet. It is not probable, however, that the amount of lime is abnormally low as calcium carbonate is present in small but appreciable quantities in the parent drift.

Roselawn sandy loam occurs in a number of small bodies in the southern part of the county. Most of the areas are gently rolling with smooth and not excessively steep slopes, and a part of the land is nearly level.

The original forest cover apparently consisted of the hardwoods, such as hard maple, beech, elm, and basswood, associated with some hemlock and white pine. White and red pines were evidently more abundant on the sandier areas.

The old, more severely burned, cut-over land is covered with stumps of hemlock and pine, a shrubby growth, consisting of aspen, oaks, sumac, witch-hazel, and fire cherry, together with briers and grasses, or it is occupied by a second growth of the original dominant hardwood forest species. Oaks apparently make a more thrifty growth than on the Grayling and Roselawn sands with which this soil is associated. A considerable acreage of the land has been placed under cultivation, but some of the cultivated land has been abandoned during the last few years. The land has some intrinsic value for agriculture but is disadvantageously located, and most of the farming is marginal.

Where the land has been farmed, oats and rye (planted alone or with vetch), timothy and red clover, corn, beans, buckwheat, and potatoes have been grown. Potatoes are probably the most successfull money crop. The land is not naturally so well suited to red

clover, alfalfa, and sweetclover as are the more limy and more fertile soils, but these crops can be grown. Apple trees make a fair growth.

In the management of the land it is probably most important to turn under green crops where manure is not available. Commercial fertilizers could probably be profitably used on the older cultivated land, especially for potatoes. Liming would probably be beneficial although under existing conditions it may not be economically practical, except where a supply of lime is available at very low cost.

ROSELAWN GRAVELLY SANDY LOAM

Roselawn gravelly sandy loam is similar to Roselawn sandy loam, except that it is more gravelly and stony both at the surface and in the underlying red sandy clay layer. This land has about the same agricultural value as the sandy loam. Some of the soil mapped with Roselawn gravelly sandy loam consists of a mixture of deep sand and sandy loam, but on the whole, it contains a little more clay at a slight depth than the areas shown as Roselawn sand. Here and there the ash-gray surface layer appears to be silty and loamy, and it is probably more fertile than typical.

ROSELAWN SAND

Roselawn sand comprises the loose, yellowish-gray sand, which is dry to a depth ranging from 3 to more than 4 feet, on the pine and oak hills. The deeper underlying material consists mainly of sand but contains scattered gravel and bowlders and in places pockets of clay. The soil is fairly uniform in that it consists dominantly of a mixture of medium and fine sand, with only a very small proportion of silt and clay. The land is for the most part free from stones, but in places bowlders and gravel pockets occur.

The content of organic matter is uniformly low and not durable. Where the soil is grass covered, as in spots on old cut-over land, the dark-gray color from organic matter extends to a greater depth than under trees. The moisture-holding capacity and the average quantity of water held is low, but it is probable that a high proportion of that present is available. The total quantity of essential plant nutrients, such as calcium, magnesium, phosphorus, and potassium, is lower than in the heavier soils and those containing a greater proportion of limestone, as in the northwestern part of the county, but there is no evidence of an abnormal deficiency of essential plant-food elements. The low fertility is compensated to some extent by the penetrability of the soil and greater freedom of root development. The reaction is strongly acid to a depth ranging from 3 to 5 feet. The gravelly areas, spots in which some clay is present between depths of 3 and 5 feet, and the dry valleys or swales between hills may be slightly more productive than typical.

Roselawn sand is one of the more extensive soils in the southeastern and eastern parts of the county. It occurs as low swells, smooth rounded ridges, and hills with broad dry swales or valleys intervening. Although there are but few streams or natural drainage ways, the land is dry or well drained, owing to the perviousness of the soil and free downward percolation of water.

The original forest consisted dominantly of red (Norway) pine with perhaps a few scattered white pine, oaks, and jack pine. The pine has been entirely cut by lumbermen, and the old cut-over land has grown up to a poor or fair growth of small oaks (scarlet, jack, red, and white), red maple, aspen, and white birch. A few scattered old red pines and most of the pine stumps left by the lumbermen remain. Bracken, sweetfern, and low blueberry are common, and in places there is a dense thicket of briers.

A very small proportion of the land has been cleared for farming, and rye, oats, corn, potatoes, timothy, and buckwheat are grown. Yields are low, and in a number of places cleared land has been abandoned after a few years of hopeless farming. The chief deficiencies of the soil seem to be low average moisture, low fertility, and high acidity. Red clover is not successful, and it does not seem probable that good stands of alfalfa or sweetclover can be obtained without liming. There are several species of grasses and weeds which are of forage value, but the cover of shrubs and trees depreciates the value of the land for pasture. Bluegrass dries up in the middle of the summer, so that the pasturage value is only fair or low. The logical use of the land at present seems to be mainly for forestry, game refuges, and hunting preserves.

Roselawn sand, gravelly phase.—The gravelly phase of Roselawn sand is distinguished by the presence of an appreciable quantity of rounded gravel and small stones on the surface and throughout the soil. The gravel consists of waterworn fragments of granitic rocks, chert, and some sandstone, with very little or no limestone. This gravelly soil occurs in large areas being especially prominent in the eastern two-thirds of the county. In its relief and drainage conditions, its value, and possibilities for future use the gravelly phase is similar to typical Roselawn sand.

KALKASKA LOAMY SAND

Kalkaska loamy sand comprises the lighter-textured and deeper sand soil of the dry sandy hardwood plains and valleys. The chief visible difference from the sands of the pine plains is in the prominent dark-brown or umber-colored loamy sand layer at a depth of a few inches below the surface. The underlying sand, beginning at depths ranging from 12 to 20 inches, and extending to a depth of 10 or more feet is pale yellow or gray, loose, penetrable, and comparatively dry. This soil is not highly fertile and is moderately or strongly acid to a depth ranging from 30 to 40 inches, but it seemingly has a little higher average moisture content and hence is a little more productive than the sands of the pine plains.

Kalkaska loamy sand is one of the less extensive soils of the county but occurs in fairly uniform bodies in the north-central and northwestern parts. The land is nearly level but is pitted here and there with shallow dry depressions and lake basins.

The original forest consisted principally of hard maple, beech, yellow birch, hemlock, elm, and ironwood, with a few scattered large white pine. A few tracts of virgin forest still remain, but the greater part has been cut over and has grown up to a second growth of maple, elm, and other species of the original forest, or, where more severely burned over, is more largely aspen, cherry, and maple,

together with a ground cover of grasses, weeds, and briers. Only a few small fields have been cleared for farming and some of these have been abandoned, but potatoes, oats, timothy and clover hay, alfalfa, sweetclover, beans, and buckwheat have been grown with some degree of success on this soil both in Crawford and in Kalkaska Counties. The soil is easily plowed, is nearly free from cobbles and large stones, but in places is rather gravelly. Its chief deficiency is probably a low moisture-holding capacity. The present type of farming over a period of years probably would not be so successful as on such soils as Coventry loam, Kalkaska sandy loam, and Roselawn sandy loam. The sand has some tendency to blow in clean-cultivated fields and, as on most of the sandy soils in this part of the State, the fields are likely to be infested with quack grass.

Heavy manuring is most essential, and it is probable that liming and the use of commercial fertilizers would increase crop yields.

Kalkaska loamy sand, gravelly phase.—The gravelly phase of Kalkaska loamy sand differs from the typical soil in having on the surface and throughout the soil large quantities of rounded gravel and small stones. This coarser material is composed of various kinds of rocks and minerals but contains little or no limestone to a depth of 3 or 4 feet. This gravelly soil occurs in small areas in the western part of the county. It has practically the same agricultural possibilities and value as typical Kalkaska loamy sand.

KALKASKA SANDY LOAM

Kalkaska sandy loam comprises sandy soil on the hardwood plains and valleys of the northwestern part of the county. It contains a small amount of silt and clay in the brown subsurface layer, sufficient to produce a light sandy loam in the plow soil in cultivated areas. The soil on forested or cut-over land consists of the following layers: (1) A 1 or 2 inch layer of mold and humus; (2) a gray or light-lavender leached sand layer from 2 to 6 inches thick; (3) a layer of dark-brown sandy loam from 4 to 15 inches thick; and (4) a pale-yellow and gray pervious and dry loose sand and gravel layer extending to a depth of several feet.

The soil is low or only medium in fertility; it is acid to a depth ranging from 30 to 40 inches but contains a small proportion of limestone gravel and crusts of calcium carbonate in the underlying sand and gravel. The moisture content is probably slightly higher than in Kalkaska loamy sand, but here also deficient moisture is probably the limiting factor in yields of farm crops.

A small acreage of the soil remains in virgin forest consisting of hard maple, beech, yellow birch, elm, and hemlock, but the greater part is cut-over land either recent slashing or old stump land which has grown up to grasses and briers and a fair or poor second growth of the original species.

The relief, drainage, and texture of the soil are favorable for cultivation and where farmed moderate success has been attained, although some farm land has been abandoned. Potatoes, hay, oats, rye, buckwheat, beans, alfalfa, and sweetclover are grown. Apple trees make a fair growth and will supply fruit at least for home use.

Manuring is essential, and probably liming for alfalfa and sweet-clover would be profitable. Commercial fertilizers have not been used to an appreciable extent, although they are probably necessary for profitable yields.

BLUE LAKE LOAMY SAND

Blue Lake loamy sand is a deep sandy soil which occupies the smooth, rolling, or moderately hilly, hardwood lands in the northwestern part of the county. The soil is very similar to Kalkaska loamy sand, but differs from that soil in its slightly greater variation in texture and the presence of a few bowlders.

The upper layers consist of (1) a layer of forest mold 2 or 3 inches thick; (2) a layer of leached gray or lavender sand 3 or 4 inches thick; (3) an 8 or 10 inch brown or umber-colored loamy sand layer slightly cemented or coherent; and (4) loose, yellow sand, in places containing shallow pockets of sandy clay, gravel, cobbles, and scattered bowlders.

The relief, texture, and structure of the soil and the drainage are favorable for farming, but because of low or only moderate fertility, remote location, form of ownership, and present cut-over condition, most of the land remains unused. Patches of this soil are being farmed, or have been farmed, west of Frederic in association with Kalkaska sandy loam and Coventry loam, but their value is considered less than that of the associated soils. In a few places, as on the scarps bordering the valley north of Frederic, the slopes are steep, but in general the land is gently sloping or only moderately hilly.

The original forest, a few virgin tracts of which still remain, consisted of a dense stand of hard maple, beech, yellow birch, hemlock, and some white pine. The land is recent or old slashing; second-growth hardwood forest; or where more severely burned over, is grown up to aspen, cherries, briers, and grasses, with old stumps and charred tree trunks remaining. As on most cut-over land, the surface has the usual pit and mound features, owing to the overthrow and uprooting of large trees.

HARTWICK SAND

Hartwick sand is very similar to Blue Lake loamy sand and Kalkaska loamy sand, differing from those soils in its weaker development of the dark or umber color of the sand lying beneath the forest mold and gray surface layer, and it is less uniform in color and texture. It occupies the moderate or steep slopes inclosing the broad valley plain in the vicinity of Frederic. The land has not been developed agriculturally and remains largely in aspen, which has grown up subsequent to lumbering, or in slash and second growth of the original mixed hardwood and pine forest.

GRAYLING SAND

Grayling sand comprises the deep, yellowish-gray sand soil of the drier pine plains. In the virgin condition it consists of the following layers: (1) A layer of mold and humous soil ranging from one-half to 2 inches in thickness; (2) gray sand from 2 to 4 inches thick; (3) dull-yellow loamy sand which becomes lighter in color at a

depth of 15 or 20 inches and grades into (4) the substratum of coarse sand, sand, and fine gravel at a depth ranging from 24 to 36 inches. The plowed soil is grayish brown or very light brown. The distinguishing characteristics of this soil are its loose consistence, incoherent or single-grained structure, sandy texture throughout, and its perviousness and nonretentiveness of moisture. The average moisture content is very low to a depth ranging from 3 to 4 or more feet, and the fertility is correspondingly low. The reaction is medium or strongly acid to a depth ranging from 3 to 4 or more feet.

This soil is fairly uniform throughout the county, but the texture of the sand varies somewhat, from medium to coarse, and the amount of gravel varies from place to place. These variations may have some slight significance, in relation to cultivated farm crops, and in relation to average moisture content and amount of plant nutrients affecting plant growth. In the open grass-covered areas the soil layer colored by organic matter is appreciably thicker and the tint is darker than in the same layer under jack pine or oaks, but the layer of humous soil is very thin in all areas and quickly disappears under cultivation.

Grayling sand, including its gravelly phase, is the most extensive soil in Crawford County, occurring in large uniform bodies in the eastern, central, and southern parts.

Areas of this soil are level, plainlike, or very slightly uneven, owing to shallow dry depressions and hummocks of wind-blown sand. The land is excessively drained and dry, owing to the perviousness of the soil and the underlying geologic formation. The water table or permanently wet sand probably lies at a depth of more than 15 feet.

The original tree growth probably consisted mainly of jack pine and red (Norway) pine; there were probably a few white pine, scarlet oak, white oak, and the jack or northern pin oak. The present growth consists mainly of jack pine, either in thickets or scattered in association with small oaks, and a scrubby growth of aspen. In the more open areas the characteristic and more common shrubs and herbs are blueberries, low willow, sweetfern, bracken, a sedge, a species of bluegrass, oatgrass, and bunch grass. The pasturage value of the land is low, and the rate of tree growth is apparently slow.

Grayling sand has very little agricultural value under present economic conditions. At the present time a few small farms are located on this soil, but attempts made to cultivate the land have been attended with poor success. Its chief deficiency is a low content of moisture during the growing season, together with low or only moderate fertility and high acidity. By the liberal use of manure or the growing and turning under of green-manure crops, by liming, and by applying fertilizers, it may be possible to obtain fair yields of sweetclover, alfalfa, potatoes, rye, turnips, and sunflowers.[7] Under exceptional conditions and by following scientific methods, possibly some of the land can be successfully used for cultivated crops. The pasturage value of the land is low, as the grasses of value for forage become dry and unpalatable in late summer or early fall.

[7] See footnote 4, page 7.

The most logical use of the greater part of the land at present seems to be for forestry and recreational purposes, at least until some more economic use for it is discovered. In places the jack pines are of sufficient size and density to have some value, and wild blueberries produce profitable yields.

Grayling sand, gravelly phase.—Areas of Grayling sand and Grayling coarse sand having a noticeably high content of gravel are indicated on the soil map as a gravelly phase of Grayling sand. Except for the higher proportion of gravel, which consists of smooth or rounded fragments of many kinds of rock, the gravelly phase is similar throughout to typical Grayling sand. There is a suggestion of a little higher natural fertility in areas of the gravelly phase, indicated by a somewhat more thrifty tree growth, and owing, perhaps, to a higher proportion of minerals other than quartz in the parent materials or to a somewhat higher moisture-holding capacity.

GRAYLING COARSE SAND

Grayling coarse sand differs from Grayling sand chiefly in texture, containing a slightly higher proportion of coarse sand. This soil probably differs very little in agricultural value from Grayling sand. The relief, moisture relations, and natural vegetation are similar on the two soils.

OGEMAW SANDY LOAM

Ogemaw sandy loam is characterized by a dark-colored surface soil, a yellow or coffee-brown sandy subsoil, in places cemented, and by the presence of clay at a depth ranging from 24 to 40 inches. The basal part of the sandy soil is more or less permanently wet, and the average content of moisture is higher than in other sandy soils, such as the Grayling, Roselawn, and Rubicon, and the fertility is a little higher. The surface soil is generally acid, although in a few places it may be nearly neutral or slightly alkaline; the sandy subsoil is strongly acid; and the clay substratum, owing to the presence of lime or calcium carbonate, is alkaline.

This soil occurs as small patches of nearly level land. Locally the land may be very uneven, owing to small mounds and pits caused by the uprooting of trees. Under natural conditions most of the soil is wet or semiswampy. The higher average moisture content is shown in the darker color and greater accumulation of organic matter as compared with the drier sandy soils, such as the Rubicon, Grayling, and Kalkaska, and the present vegetal cover and the composition and character of the original cover also indicate the higher average moisture content and greater fertility.

The original tree growth consisted mainly of white pine, which in places must have attained very large size, judging from stumps, with a mixture of hemlock and the hardwoods, such as elm, ash, basswood, and beech, together with more or less spruce, fir, and arborvitae. The land has been completely cut over by lumbermen. The present cover of the wild land consists of a dense brushy growth of aspen, alder, willow, and briers, with scattered clumps or individuals of the hardwoods and other original species.

Small patches here and there are farmed, but the greater part remains as wild land or stump pasture. The soil is easily plowed and tilled when cleared of stumps and roots and leveled. Potatoes, corn, oats, rye, timothy and clover hay, and other crops have been grown with fair results. Plant growth is not uniform, however, owing to variations in the moisture conditions and the content of organic matter. The cut-over land is for the most part thickly set with stumps, and the cost of clearing and leveling is high. Where the brushy second growth has been kept down by fire or other means, the land affords good grazing for cattle and sheep.

A few small patches of Selkirk loam, from 1 to 4 acres in extent, are included with Ogemaw sandy loam as mapped. Selkirk loam is a heavier soil occurring on nearly level land. The surface layers are dark-gray, ash-gray, and yellowish-gray silt or fine sand, and comparatively impervious pale-red or chocolate-colored clay occurs at a depth ranging from 6 to 20 inches. This included soil is a little more productive than Ogemaw sandy loam.

RUBICON SAND

Rubicon sand consists of deep-yellow comparatively dry sand on pine plains and sandy valleys. A dark-brown layer of loamy sand or sandy loam occurs at a depth ranging from 6 to 12 inches below the surface, and beneath this is loose pale-yellow, gray, and rust-colored sand. The land is level, and the soil is intermediate in drainage and average moisture conditions between Saugatuck sand and Grayling sand, with corresponding intermediate development of the gray and yellowish-brown subsurface layers characteristic of most of the soils of this region. The soil is highly acid and low in fertility, but probably supports a little greater amount of vegetation than Grayling sand because of slightly higher average moisture content.

The original forest growth probably consisted dominantly of white pine and red (Norway) pine, with a smaller amount of hardwoods. At present there is a poor to fair second growth of oaks, aspen, white pine, jack pine, and white birch, together with a few widely distributed individuals or clumps of the original white pine and red pine. Stumps of the original pines remain in most places.

The land is practically unused for cultivated crops, and the pasturage value is only fair. Probably fair crops of potatoes, alfalfa, sweetclover, oats, and hay could be obtained on this soil by liberal manuring, fertilization, and liming.

Rubicon sand, gravelly phase.—The more gravelly areas of Rubicon sand are indicated on the soil map as a gravelly phase, as the only appreciable difference from the typical sand lies in the greater content of rounded gravel. This more gravelly soil seems to be a little more productive than typical Rubicon sand.

SAUGATUCK SAND

Saugatuck sand is a moist sandy soil characterized by a brown sandy hardpan. This soil consists of the following layers: (1) A dark-colored mixture of peaty organic matter and sand overlying (2) a light-gray or dingy-white loose sand layer from 6 to 12 inches

thick, underlain by (3) dull-yellow or coffee-brown sand, in places cemented into a hardpan, from 6 to 15 inches thick, which grades into (4) gray or mottled gray and yellow sand. The soil is frequently water-soaked within a few inches of the surface and permanently saturated at a depth ranging from 3 to 4 feet, but at certain times throughout the summer and fall it may become very dry to a depth of a foot or two. In most areas clay occurs at a depth below 4 feet. The sand consists dominantly of medium and fine sized particles.

The soil is strongly acid in reaction, is low in lime, and is low in fertility under cultivation, although it supports, under natural conditions, a dense tree growth and a heavy cover of other vegetation. Where this soil has been plowed and cultivated elsewhere in the State, the organic matter has been rapidly depleted, leaving the soil a lighter color and less loamy within a few years.

Saugatuck sand is not widely distributed in Crawford County, occurring principally in small bodies or in long strips within or bordering swamps. The areas shown on the map are not uniform, but include dry hummocks or narrow short ridges of Rubicon sand, spots of muck, and of Newton and Ogemaw soils. The land is for the most part flat, wet, and semiswampy, and cut-over areas are characterized by shallow pits and mounds due to the overthrow of large trees. The wetter spots support a dense shrub or thicket growth of aspen, willow, alder, and white birch, and in places bracken, blueberries, and a ground cover of wintergreen grow. The original forest growth over most of this land was white pine, with red (Norway) pine on the drier sandy spots, and some spruce, hemlock, fir, and cedar on the wetter land. Hardwoods, principally yellow birch, aspen, elm, and ash, were originally present in small numbers. Little reproduction of the original species has taken place since the land was logged over by lumbermen, and in most places large white-pine stumps remain.

This land has very little agricultural value under present conditions, either for cultivated crops or for pasture, but as it supports a fairly large amount of vegetation, it should have considerable value for forestry and recreational purposes. Trees, for Christmas trees, posts, and fuel, blueberries, and wintergreen are natural products of some value.

OTTAWA LOAMY SAND

Ottawa loamy sand, to a depth ranging from 4 to 6 feet, is loose and incoherent fine or medium yellow sand, directly overlying compact, comparatively impervious red clay. The sand is comparatively dry and is well aerated to a depth ranging from 2 to more than 3 feet.

In the mapped areas of Ottawa loamy sand considerable variation occurs in the thickness of the sand over the clay, and a small amount of darker-colored wetter soil in swales or depressions is included. Some deep sand also has been included which shows little or no difference from Roselawn sand or Rubicon sand.

Ottawa loamy sand contains only a low or moderate amount of organic matter, is not high in natural fertility, is medium or strongly acid in the sandy layers, and is alkaline in the clay substratum. The sand is usually moist, in many places saturated, at the contact with

the clay substratum, and the average content of moisture in the surface layers may be slightly higher than in the Grayling, Rubicon, and Roselawn sands.

The relief ranges from level to slightly undulating and gently rolling. The soil occurs in small scattered areas over the plains in the eastern part of the county.

The original forest growth consisted mainly of white pine. Probably some red (Norway) pine and a few jack pine grew on the deepest sand, and some hemlock and a small amount of hard maple, beech, and other hardwoods where the sand was thinnest. A few of the original forest trees remain, but scarcely any natural reproduction of the original species has taken place since lumbering ceased. At present the trees are mainly oaks, which show a fairly thrifty growth, red maple, and aspen. Where the brushy second growth has been kept down by fires or by cutting, the land affords fair grazing for sheep and cattle. Bluegrass is the most abundant grass; timothy and red clover, which have spread from old logging camps or cultivated areas, grow wild in places.

A very small proportion of the land has been cleared for farming, and potatoes, rye, buckwheat, corn, oats, beans, timothy, and red clover are grown. Probably in a few places fairly satisfactory yields have been obtained, but the growth on fields of any considerable size is likely to be spotted and variable, owing to differences in the thickness of the sand and in moisture conditions.

With proper management the land may offer some possibilities for farming at the present time, but it is regarded as inferior to Coventry loam, Roselawn sandy loam, and Kalkaska sandy loam.

BRIDGMAN FINE SAND

Bridgman fine sand comprises dry fine sandy land occurring as low ridges or moundlike areas which represent old dunes or ridges of morainic sand. The soil consists of pale-yellow or grayish-yellow fine sand to a depth ranging from 8 to more than 10 feet and shows wind or water stratification. It differs from other loose dry sand by its greater uniformity in texture and color to a greater depth, and by the absence of a conspicuous brown layer. The sand is strongly acid and low in productiveness. Only a few small areas are mapped. The soil has little or no agricultural value at present because of low fertility, strong acidity, and tendency to drift or blow under wind action.

The original forest growth was largely white and red (Norway) pine. At present the land supports oaks, jack pine, red pine, and aspen, with an undergrowth of blueberries, bracken, sweetfern, and grasses.

BERGLAND CLAY LOAM

Bergland clay loam includes the heavier mineral soils of the county which have developed under poor drainage conditions. It occurs as swampy land in swales, on slopes where there are seepage springs, and on the borders of peat and muck swamps. The surface soil is dark-gray or nearly black, owing to a high content of organic matter, and to plow depth is loam or clay loam. It is underlain by a gray or drab plastic clayey layer which passes into bluish-gray or gray and

yellow clay showing the physical and chemical properties common to clay soils existing under permanently wet conditions. At a depth ranging from 2 to 5 feet the material has the red color common to the glacial-drift clay of this region. The soil seems to be fertile and is alkaline or nearly neutral in reaction, but very little agricultural use has been made of it because of its occurrence in small bodies and because of the excessive cost of draining and clearing the land. Native grasses and alsike clover and timothy, which grow wild, afford good pasturage where the land has been cleared of trees and brush. The cover of natural vegetation was dense and consisted mainly of elm and ash, with smaller amounts of aspen, soft maple, basswood, spruce, fir, cedar, hemlock, and white pine. Some small open spots are covered by cattails, flags, and sedges. The total acreage of this land is small.

BERGLAND LOAM

Bergland loam is very similar in occurrence and other respects to Bergland clay loam, but includes soil which is on the whole sandier. However, it contains considerably more clay than does Newton loamy sand, and it is wetter than Ogemaw sandy loam. The sandy or more loamy layer overlying the clay may be slightly acid in this soil. Practically none of the land is used for agriculture, but it should be good pasture and hay land where cleared of trees and brush.

NEWTON LOAMY SAND

Newton loamy sand consists of dark-gray or nearly black loamy sand and sandy loam, underlain by light-gray or dingy-white wet sand and, at a greater depth, by gray and yellow mottled sand or sandy clay. The dark color, owing to an accumulation of organic matter under wet conditions, extends to a depth ranging from 3 to 15 inches. The soil is medium or strongly acid in reaction in most places and does not show evidence of high fertility other than in the organic matter contained in the surface layer.

This soil occurs on poorly drained sand plains, on the flat wet borders of shallow lakes, and on the borders of peat swamps. In mapped areas considerable shallow muck or peat is included, also small bodies of Saugatuck and Rubicon sands.

At present most of the land is covered by a dense thicket of alder, willow, and aspen. The original tree growth consisted mainly of white pine with more or less white cedar, spruce, fir, and locally yellow birch, red maple, ash, elm, and aspen were abundant.

The land is considered of very little agricultural value under existing conditions. A few acres are used for pasture and hay land, but artificial drainage is necessary for any other use.

GRIFFIN SANDY LOAM

The streams of the county for the most part flow through peat swamps, but along the lower courses of some of the larger ones are comparatively narrow strips of wet or swamp bottom land composed of alluvium carried by the streams and deposited during occasional overflows. Most of this alluvium consists of a comparatively thin layer of gray, yellow, or rust-colored sand or sandy loam, which has

been classified as Griffin sandy loam. It contains a high proportion of organic matter and is rather fertile, but because of poor drainage, a high water table, and narrowness of the bottoms, has no agricultural value under present conditions.

The bottoms originally supported a dense growth of mixed hardwood and coniferous trees and a dense shrubby undergrowth. The tree growth included elm, ash, red maple, balm-of-Gilead poplar, and aspen, together with some cedar, white and black spruce, fir, tamarack, alder, and willow.

ORGANIC SOILS (MUCK AND PEAT)

The organic soils are composed dominantly of plant matter and in this respect constitute a distinct class when compared with the soils composed dominantly of mineral or inorganic matter. In Crawford County the organic soils occur in swamps, heath bogs, and marshes. The deposits have accumulated in such permanently wet situations as the following: (1) In irregular-shaped flat areas where underdrainage is obstructed and in stream valleys, (2) on slopes permanently wet from seepage springs, and (3) in certain types of lakes, some of which have been completely filled by vegetation. The deposits composing the organic soil, or from which the soils have been derived, range in thickness from 1 foot to as much as 40 feet; differ in the nature of the mineral substratum, whether marl, sand, or clay; differ in the average depth of the water table; and also differ in age, stage of decomposition of the plant matter, ash content, and amount of admixture of foreign mineral matter. These soils comprise about 9 per cent of the total area of the county. Their agricultural value at present is low, and there seems to be little probability of any extensive use of the areas because of their location and the climatic and economic factors to be overcome. On account of the great amount of time and labor involved, and the small economic justification, no attempt has been made to show on the map more than a few of the subdivisions of the organic soils, but fairly well-defined types or groups are recognized, although the boundaries between them can not be expected to be as accurately drawn as for the mineral soils. The less decomposed and coarser organic soil is differentiated as peat and the more decomposed as muck.

Rifle peat.—Rifle peat is a brown or dark-brown coarse woody or loamy material, very high in organic matter (75 per cent or more), which is underlain at a depth ranging from 6 to 20 inches either by a fibrous or by a coarser-textured woody mass of plant matter showing very little decomposition. The average depth of the water table is probably between 10 and 20 inches. Rifle peat gives an acid or nearly neutral reaction. The mineral substratum in most areas is sand.

The vegetation consists of a dense growth of arborvitae (locally called white cedar), black spruce, balsam fir, and tamarack, with an occasional hemlock and white pine. On included islands in the swamps there was originally or still remains considerable maple, birch, and aspen. Where the swamp land has been logged off and burned over, the land has grown up in places to dense thickets of aspen, alder, willow, and white birch, and treeless open places support a heavy cover of sedge (such as *Carex filiformis*) and bluejoint. In

places vegetation of the more acid bog type (Greenwood peat), such as leatherleaf, Labrador-tea, blueberry, and laurel, occurs in association with the tree growth.

The land has little or no agricultural worth and its value, for the present at least, consists chiefly in the tree growth which it is capable of producing and as game refuges. Some sedges and grass are cut for hay from a few areas.

Rifle peat occupies the largest acreage (80 per cent) of the muck and peat land of the county. It occurs throughout the county both in the stream-valley and the lake-filled swamps. The largest individual bodies are in the vicinity of Grayling, west of Lake Margrethe, and east and northeast of Lovells.

Within the larger bodies very small islands of Saugatuck, Rubicon, and Newton soils probably remain unmapped, because of the impenetrability of the swamps and the difficulty of drawing accurate boundaries.

Lupton muck.—Lupton muck is black or brown granular loamy muck, high in organic matter, comparatively high in ash content, comparatively fine in texture, and showing such evidence of marked physical change and decomposition of the parent plant matter at the surface that botanical identification of the plants is difficult or impossible. This material is 10 or 12 inches thick and, in some places, extends to a depth ranging from 2 to 3 feet before the usual yellow or brown coarser, more fibrous, and less decomposed peaty material is reached. Lupton muck is for the most part nearly neutral or but slightly acid in reaction. The water table under natural conditions is probably at an average depth between 18 and 30 inches. The vegetation now includes or originally included a large proportion of elm, black ash, aspen, and soft or red maple, in association with the characteristic coniferous species of the swamps of this region, such as cedar, spruce, fir, and tamarack, a small amount of hemlock and white pine, and an occasional basswood.

This type of muck occupies a comparatively small acreage but is widely distributed over the county. It occurs in the valleys of the larger streams and in small irregular bodies in association with the more clayey soils and more calcareous glacial deposits. In a few places it is underlain by marl, but in most places the substratum is sand or clay. The land has practically no agricultural value at present in Crawford County, although a similar type of muck has been used with some success for special crops, pasture, and a few of the general farm crops in the southern part of the State. It produces fair pasturage when cleared and is capable of producing thriftier tree growth than other types of organic soil.

Greenwood peat.—Greenwood peat is fibrous or coarse-textured, loose or uncompacted, brown or yellow material which shows very little decomposition of the plant matter even in the surface layer. It is uniformly very strongly acid in reaction. The water table is at or within a few inches of the surface, although in very dry periods it may sink to a foot or two. Deposits accumulated in deep lakes are commonly underlain by water or soft soupy peat, and would be subject to great shrinkage in thickness if the land were drained. Land of this kind is characterized by open heath bogs of leatherleaf (Cassandra), Labrador-tea, blueberry, laurel, cranberry, cotton grass, and Sphagnum moss; in places there is a small,

dwarfed growth of tamarack and black spruce, also a few red and jack pines. Some of the more open land is marsh or meadow covered chiefly with sedges.

This highly acid soil occurs in widely distributed small bodies representing the sites of small lakes which have been filled in by the accumulated remains of vegetation, and it also occurs in larger bodies as recent accumulations on poorly drained sandy flats. The land has no agricultural worth except the remote possibility of its use for growing such crops as blueberries and cranberries. The Sphagnum moss and blueberries which the bogs yield under natural conditions may have some present or possible future value. The tree growth is of practically no value.

Kerston muck.—Kerston muck occurs in the swamp land traversed by the main branches of Au Sable River. It is a dark-colored muck or peat, similar to Lupton muck and Rifle peat, but contains considerable alluvial matter, sand or silt, either mixed through the plant matter or in separate layers. Areas of this material grade into Griffin sandy loam, or are so dominantly organic that they are not materially different from the Lupton, Rifle, and Houghton types of organic soils. Most of the land lies from 1 to 3 feet above the level of the streams, and is forested with spruce, cedar, tamarack, alder, willow, aspen, white birch, elm, ash, and red maple. The land has no agricultural value at present.

Houghton muck.—Houghton muck consists of dark-brown or black finely fibrous plant remains. This material is loose, or not compact, is nearly neutral or moderately acid, and contains very little admixed mineral matter. The underlying material may be black, fine in texture, and pasty or cheeselike. The water table under natural conditions is very near the surface. The plant matter contained in Houghton muck is somewhat less loamy and less decomposed at the surface than in Lupton muck, and it is less strongly acid, darker in color, and finer in texture than in Greenwood peat, but some peat is included which shows no difference from Greenwood peat other than the absence of woody matter and roots of shrub vegetation.

Houghton muck occurs in only a few small, scattered bodies. The natural marsh vegetation consists dominantly of a sedge (*Cærex filiformis*), bluejoint, and in places a few stunted alder, willow, and aspen bushes. The land has no agricultural value at present, but may have some value as breeding and feeding grounds for muskrats and birds.

CLASSIFICATION AND ORIGIN OF THE SOILS

The taxonomy, morphology, and evolution of the soils of Crawford County are discussed briefly in the following pages.

The two soil groups represented in the county are what are ordinarily designated mineral soils and organic soils. The mineral soils comprise about 91 per cent of the total land area and the organic soils about 9 per cent.

The mineral soils consist of two major taxonomic divisions based on the average amount of water in the solum: (1) A division containing normal moisture for the region which is equivalent to a division of well-drained soils; and (2) a division in which free water

exists permanently, or for considerable periods, to the point of complete soil saturation and water logging. The first division is estimated as occupying about 83 per cent of the total soil area, and the second about 8 per cent.

The group of well-drained mineral soils which have completely developed profiles are podsolic, though true podsols cover only a small part of the area. They are all podsolic in that leaching and the translocation of sesquioxides, particularly the removal of calcium and magnesium carbonates, are dominant in the soil-forming processes. Some of the soils are transitional in character, for example Roselawn sand and Nester loam, but none is exactly comparable to the soils of the extreme southern part of Michigan or to the soils of the forested region of central-eastern United States, which comprise the group of gray-brown forested soils of the United States.

The generalized profile for the virgin soil of normal moisture and of mature soil profile in northern Michigan is as follows: (1) An accumulation of litter and peaty forest mold; (2) a very thin humous soil layer; (3) a highly leached gray layer; (4) a layer of brown or yellow humic and iron oxide coloring; (5) a layer of maximum clay content; and (6) the parent material, or geologic substratum.

This group is represented by the three following subgroups differentiated on the basis of the texture and consistence in the successive layers in the profile or soil section: (1) A subgroup underlain by clay which is comparatively dense and impervious in layers 4, 5, and 6 of the generalized profile described; (2) a subgroup underlain by sand and gravel or comparatively loose and pervious material in layers 4, 5, and 6; and (3) a subgroup having more clay-colloid material in layers 4 or 5, whereas layer 6 is less clayey and more pervious.

These groups are still further differentiated into soil series and types, described in preceding and succeeding pages, on the bases of differences in color, texture, structure, chemical characteristics, and thickness of the various layers.

Layers No. 3, representing maximum eluviation, and No. 4, humic coloring, are the outstanding features of the complete profile. It appears that these layers reach their maximum development in thickness, intensity of brown or yellow color, and removal of inorganic colloids, in areas where the parent material is sandy and under conditions of moderately high average moisture; whereas at the other extreme the minimum development occurs where the parent material is either comparatively impervious clay or very dry sand and gravel. The normal thickness of layer 3, the gray highly eluviated layer, is from 4 to 8 inches, but under exceptional conditions may be from 18 to 24 inches. The thickness of the brown, or humic, layer 4 is commonly from 6 to 12 inches and the maximum thickness is 36 inches, although the base of this layer is not sharply marked especially where the parent material is loose sand. Under certain conditions, layers 4 and 5 coalesce as a single layer, and maximum intensity of humic coloring is ordinarily at the top of the layer. Field observations tend to indicate that the darkest-brown or umber color occurs where the sand or gravel contains the largest amount of calcium carbonate or magnesium carbonate, although it is apparent that a

certain moisture condition is the dominant or controlling factor. The maximum content of iron oxide and maximum cementation in this layer appears to exist in such soils as the Saugatuck, where there is a frequent saturation and a high water table but also a wide range, or fluctuation, in the content of water throughout the year.

The thickness of surficial litter and mold under an old or mature unburned virgin forest and under conditions of good drainage is normally from 3 to 4 inches in this region. This increases as the moisture conditions approach those of swamp, whereas at the other extreme there is no more than 1 inch of fluffy organic matter from grass, lichen, and moss on Grayling sand and Grayling coarse sand on the open driest sand plains. True humous soil, such as occurs in the subhumid prairie region of the United States and in the gray-brown forested soils of the central and eastern parts, is absent or is developed only as a very thin layer. The greatest amount of humus (highly decomposed or completely altered organic matter) is present, other conditions being the same or similar, where the parent material is most limy or basic and the moisture comparatively high, but not to the point of saturation.

Layer 5 is weakly developed and shows no evidence either of marked clay concentration or of intense coloring by ferric oxides developed in the soil-forming processes. A layer containing a higher proportion of clay or colloids than the parent material is less evident than in the southern part of the southern peninsula of Michigan, and notably less than in the central and southern parts of the United States. The development of such a layer in northern Michigan is most noticeable in coarse gravelly calcareous material. Only slight intensification of ferric oxide coloring over that of the parent material occurs in the heavy clay.

The depth to which carbonates have been removed from the soil in the soil-forming processes is in general from 30 to 48 inches, but varies, of course, with the amount originally present, the texture of the parent material, the surface configuration, and the age of the soil. In dense clays complete removal has taken place to a depth ranging from 18 to 30 inches, whereas in some sands there appears to have been complete removal to a depth of 5 or 6 feet. In some other soils, where the parent material consists predominantly of sand, gravel, cobbles, and bowlders, some limestone rock may remain throughout the profile, although such soil is scarcely represented in this county. Phosphorus and potash are also removed in the soil-forming processes, especially in layer 3. Nitrogen is highest in the surface layer of organic accumulation and is also present in appreciable amounts in layer 4. Where the parent material is friable sandy clay drift and a compact No. 5 layer is developed, a second layer of leaching between layers 4 and 5 is present. The thickness of the solum is generally from 30 to 40 inches and so far as this is indicated by alteration or development of color due to weathering, it appears to be no thicker in the loose, driest sands than in the densest, most impervious clays.

The mineral soils developed under conditions of poor drainage or excessive moisture have the following generalized profile: (1) A dark-gray or black surface layer consisting, in part, of accumulated organic matter; (2) a gray or drab layer, not colored or but slightly colored by organic matter; (3) a layer containing a maxi-

mum amount of clay and having a maximum degree of coherence or plasticity, or one containing maximum yellow or brown coloration and cementation from iron oxides; and (4) the substratum, or parent material. Leaching is greatest in layer 2, and this layer reaches its greatest thickness where the parent material is sand. These soils are also leached of carbonates but apparently not to so great a depth as the well-drained soils, and are generally higher in fertility measured by the total amount of nitrogen, calcium, phosphorus, and potash, given the same parent material. Where the parent material is calcic or basic, the soils commonly show an alkaline or neutral reaction from the surface downward. Where the parent material is sand, layer 3 commonly shows a marked or even solid yellow or brown color from humic matter and iron compounds and may be more or less cemented into a hardpan.

Mineral soils with incompletely developed profiles are represented in this county mainly by recent alluvium in the valleys of the streams. Most of this material has a high average moisture content or occurs as swampy or semiswampy land. The alluvium is purely local in origin, and commonly contains a high proportion of organic matter, sufficient to mask the rock color at the surface. In many places the deposits consist of alternate layers of mineral alluvium and muck in which the muck or peat is partly transported but mainly accumulated in place. Colluvial sandy wash in dry valleys, blow sands, beach deposits, and the wave-washed strand along lake shores, are of very small extent in this county. Soils having incomplete profiles, owing to erosion under natural conditions, also occur but are almost negligible in total acreage.

The group of organic soils is represented by a number of types which range considerably in chemical and physical properties; both young and old soils are represented although none of the soils appears to have developed quite as complete alteration or alteration to as great depths as in the southern part of Michigan. Practically all are high in organic matter, that is, they contain 75 per cent or more of material combustible on ignition. The greater number of deposits appear to have been accumulated in valleys or on permanently wet flats rather than in lakes, although the lake-filled deposits are also represented. Deposits, in general, do not reach a great thickness, but in most places are more than 3 feet thick. On the sites of lakes they are, in places, from 20 to 30 feet thick or even thicker. Most of the thin deposits are underlain directly by sand, and deposits underlain by marl and clay are much less common than in other parts of the State. The deeper lake-filled materials present the common sectional characteristics, that is, they consist of pasty or gelatinous green or gray material at the base and a succession of layers varying in texture and composition according to the stages in plant succession which range from aquatic plants to forest trees.

Complete alteration, represented by an almost black or dark-brown color and complete destruction of the botanical character of the plant remains, is not common and in the oldest deposits generally does not exceed 10 or 12 inches. In the most acid peat type, Greenwood peat, there is practically no alteration, although there is a much greater range in fluctuation of the water table than in the more woody and less acid types, such as Lupton muck and Rifle peat. A small part of the Greenwood peat is nearly neutral in reaction and comparatively

high in lime, but the greater part ranges from moderately acid to very strongly acid. In general, the most acid organic soils are associated with the sands and the least calcareous phases of the glacial deposits, but in a number of places the acidity seems to be dependent on the height of the water table and on the rawness or lack of decomposition of the plant matter, as the adjacent soils and drift may be limy and the drainage waters alkaline. The characteristics of organic soils, like the characteristics of mineral soils, are probably determined by the climate modified to greater or less extent by the influence of the geologic formations and the physiography of the region in which they occur. Thus, it seems probable that the oldest organic soils in this region can not reach so complete a state of decomposition as organic soils in regions farther south, and that the texture and consistence of the organic soils differ because of the differences in temperature and in the plant species composing the parent material.

In the classification and mapping of soils the lakes are largely of academic interest at present, but, nevertheless, justify some consideration as an economic factor, as they support vegetation which has a food or protective value for fishes, aquatic birds, and mammals, and in addition they have some possibilities for the production of feed for farm animals and for the production of certain plants otherwise useful to man. Thus considered the lakes, with their bottoms, may be conceived of as consisting of three master horizons, or layers: (1) The surface layer, the aqueous or liquid member; (2) the cumulose or sedimentary intermediate member, consisting, for example, of an ooze or a soft gelatinous mobile mass of animal or plant remains, of peat, or of a soft penetrable mineral mass representing recent sedimentation or precipitation; and (3) the old geologic substratum. The waters thus can be subdivided most logically on the basis of physical and chemical differences which theoretically have a determining influence on the kind and character of plant growth. The chemical composition of the water, particularly whether acid, alkaline, or saline; the thickness or depth of the water covering; the chemical character of the second and third layers considered as to fertility; and their lithologic character and texture, whether marl, peat, sand, clay, or hard rock, serve as bases for subdivisions, to whatever degree it may be practicable to carry a classification. No attempt has been made in this survey to classify and show the distribution of the different types of lake materials on the map, although some facts of an observational nature can be stated.

The lake waters are generally clear or free from mineral matter in suspension, and are generally alkaline in reaction, due very probably, to the presence of calcium and magnesium bicarbonates; sand and peat bottoms are most common; marl occurs in only a few places and is not so widely distributed as in the central-southern part of the State; and hard-rock bottoms seem to be entirely absent. Lake levels are comparatively uniform. In most of the bogs largely occupied by such plants as leatherleaf (Cassandra), blueberry, and Sphagnum moss, the standing water is acid in reaction and the coarsely fibrous or stringy underlying peat is highly acid. The stream waters are predominantly alkaline in reaction, and are clear, that is, they are generally free from suspended mineral sediment,

but where issuing from or flowing through peat swamps, they commonly have a brown or straw-colored tint caused by suspended or dissolved organic matter. The bottoms of most of the stream channels are sand or peat. The streams have a moderately rapid flow after leaving their sources in swamps and lake basins, and in general are not subject to rapid rises or fluctuations in level.

Common hydrophytic plants in Crawford County are white and yellow pond lilies, pondweed (Potamogeton), bladderwort, chara or musk grass, water milfoil, arrowhead, bogbean (buckbean), lake bulrush (Scirpus), cattails, and sedges (species of Carex).

All the soils which have been differentiated here occur in gradational series according to differences in the moisture or drainage conditions under which the soil has developed. This gradational character of soil types is universal, and under such conditions the limits established for each soil type must necessarily be arbitrary and each type must include soil of a transitional character.

In northern Michigan a more or less complete moisture series can be recognized for each of the following classes or groups of parent material: (1) Moderately pervious stony and sandy friable clayey drift; (2) loose, incoherent sand; (3) massive fine-grained compact clay; (4) sand over impervious clay; (5) pervious unconsolidated sand, gravel, and cobbles; and (6) peat. The degree to which alteration of the parent material has taken place under the different moisture ranges possible, is determined by the climatic conditions and the period of time during which soil-making processes have operated. In each of the parent material groups listed there is a fairly wide range of moisture conditions and a corresponding range or gradation in chemical and physical differences which constitute the basis of differentiation of the soils into types. For example, given parent material of sand, conditions may range from swamp, in which the sand is covered with muck or peat and bleached or mottled beneath (Newton loamy sand) to the driest condition, where the mold and humus is extremely thin and dry and where there is little or no development of gray and brown layers or leaching of iron oxide color (Grayling sand).

A knowledge of the lithologic character and of the forms of the glacial deposits becomes important in the explanation of facts about the chemical and physical character of the soils and their geographic distribution, and for speculation on their evolution. In this county there is the usual admixture of detritus from the rocks of the northern part of Michigan and Canada, and the usual heterogeneity in rock composition, but perhaps less rock from purely local sources than in other parts of the State where the drift cover is much thinner. Here the covering of unconsolidated deposits over the old Paleozoic formations is from 300 to 600 feet thick.[8] Although there appears to be less limestone in the drift in this region than in other parts of the southern peninsula, there is a small but appreciable influence from limestone and shale from the Devonian and Silurian formations to the north. This influence appears to be strongest in the northwestern part and decreases eastward and southward, as may be

[8] LANE, A. C. MAP SHOWING GEOLOGICAL FORMATIONS AND CONTOURS OF ROCK SURFACE OF THE SOUTHERN PENINSULA OF MICHIGAN. REVISED FROM STATE REPORTS AND UNPUBLISHED DATA. In Leverett, F., and others. Flowing Wells and Municipal Water Supplies in the Middle and Northern Portions of the Southern Peninsula of Michigan. U. S. Geol. Survey Water-Supply Paper 183: map between pp. 8 and 9. 1906.

inferred from the soil map in the distribution of Kalkaska and Blue Lake soils. The glacial clays, which comprise only a small proportion of the drift, are only moderately calcareous, and show only a faint red color. The more arenaceous or coarser-textured drift is gray or yellow in color and covers a much greater area. Consequently there is less evidence of bright hematitic red color than in some other parts of northern Michigan and a great predominance of sands and sandy loams over loams and clays.

The diversity of soils, their intimate association in many places in small bodies, and the textural gradation of one soil into another are traceable to the lithologic heterogeneity and range in texture of the parent soil material, to the variations in thickness of relatively pervious material over relatively impervious material, resulting in a wide range in moisture conditions. There is also a diversity in the surface configuration of the Pleistocene formations, such as moraines, outwash plains, till plains, and old glacial drainage valleys.

The formations were laid down during the last stages of the glacial period (the Wisconsin), so that the land surface is relatively young. The surface configuration is almost entirely constructional, as streams have not yet had time to develop complete dendritic systems, so that large areas remain flat and wet, and mineral soils have developed under conditions of excessive moisture together with the accumulation of peat deposits. On the other hand, soils developed under conditions of low moisture have been possible because of the perviousness and great thickness of some of the glacial deposits, notwithstanding that the surface may be level. This is particularly true of the outwash plains. Various wet and dry conditions and differences in soil types on the moraines are the result of differences in the texture and composition of the glacial débris rather than the result of stream erosion or slope of the land surface. The change from Kalkaska or Blue Lake soils to Roselawn sand on the same moraine without change in relief may be accounted for by a corresponding change in the amount of limestone and shale and coarse matter in the drift. Generally, the more gravelly and cobbly drift, both in moraines and outwash plains, produces the more loamy soil. The generally moist conditions on till plains is ascribed to the more clayey character of the underlying deposits and to the smoother, less rolling relief.

The natural vegetation, as is universally true, has been a factor in the development of soil charactertistics; but, as is also generally true, the vegetation is both a cause and effect of soil differences. In this county the whole area, excepting the very small acreage of lake surface, marsh, and peat bog, was originally forested. Most of the forest cover was dense, even junglelike in some of the wetter situations, but in some of the drier situations, as on the dry plains, there was a comparatively open growth of pines with a shrub and herbaceous undergrowth. The woody character of the surface accumulation of organic matter and the thickness of the humous soil and of the underlying gray and brown layers, if not wholly, at least in part, are attributable to the forest vegetation. Any constant relationship of thickness or intensity of coloring of the several layers to a particular type of forest vegetation is not apparent, but the texture of the soil material and the average moisture content seem to be the dominant controlling factors. Equally strong or equally weak

developments of the various layers occur under all the different types of forest other than the swamp type and the dry pineland type. The composition, texture, and other physical properties of the organic soils are clearly related to the kind of vegetation growing on these soils; and on the dry sand soils, such as Rubicon, Grayling, and Roselawn sands, the grasses and other herbaceous vegetation, together with mosses and shrubs, such as blueberry and sweetfern, have had an influence in determining a soil profile different from that of other soils. Influence from types of vegetation which preceded the present may be assumed although too little is known about the plant succession and histology, as shown in the soil profile, to venture a statement of the specific character of such influences, except in the peat deposits.

The progressive changes in the present soil profile are probably toward continued leaching and, therefore, toward an increase in the thickness of the eluviated solum. In some of the sandy soils, the leaching process, resulting in the development of a gray layer beneath the forest mold, is as nearly complete as possible, at least in thickness, so that uninterrupted leaching would result in increment to the brown humic layer and further eluviation of the deeper layers. In the sandy clay material, the present processes if continued could be expected to result in the intensification of the brown humic layer and the further development of a B horizon through addition of clay, or in cementation and a consequent increase in a secondary layer of leaching between this and the brown humic layer. In the heaviest clays there should be an increase in the thickness of the gray eluviated layer and subsequent intensification of the brown humic layer, which is at present weakly developed.

There is a suggestion of retrogression in profiles in the partial destruction of the brown humic layer in ridges of deep dry sand which show a profile developed under wetter conditions than exist at present. There is also, in a number of places, evidence of a rise in the water table, through continuous accumulation of water on flats and seepage slopes, and the accumulation of peat, with a consequent change in the profile of bordering soils which were at one time relatively dry. As evidence of this, some of the larger swamps contain numerous low islands of dry sand; and the presence of jack pine on peat and wet mineral soils, such as the Newton and Saugatuck soils, might be considered as evidence of a former drier condition. On the other hand, there is evidence of a general physiographic change because of stream cutting, resulting in the lowering of the water table in wet flats and peat swamps and consequent changes in soil, due to land elevation and tilting.

In a glaciated region, such as the southern peninsula of Michigan, where there is a comparatively thick covering of glacial drift from a variety of sources, with a diversity of topographic forms and drainage conditions, without, however, any relief features of magnitude and no sharply separated physiographic divisions, a blending or intergradation of soil types and also of the larger groups of soils would be predicted from these basic facts and from the postulations of pedology. A complete range exists in size of soil particles from the finest measurable to stones; in soil of a given texture the amount of moisture is constantly gradational from a saturated or water-

logged condition to the dryness of the jack pine sand plains; a wide range exists in the quantity of the separate elements and in the quantity of a particular compound as for example, calcium carbonate; and, finally, the degree of profile development ranges from practically no change in the parent material to the most maturely developed soil profile of the region. It follows, therefore, that in practice the permissible range or latitude in texture, moisture content, composition, and thickness, or their tangible expressions, must to some degree be arbitrary. From the nature of things, the soil type, the unit of soil mapping, as at present defined, is not permanently fixed but rather is empirical and is designed to meet the present needs of a soil classification.

The various soil types differentiated in this county, taxonomically considered, are discussed in the following paragraphs.

Soils of the Roselawn series consist of yellow sand and light sandy loam to a depth of more than 3 feet, underlain by a heterogeneous substratum of sandy drift. These soils in Crawford County are transitional, differing but slightly from the Coloma soils of the southern part of the State. They present some divergence from the Roselawn soils of the western part of the northern peninsula in that the gray, or leached, layer is less strongly developed, less red iron oxide coloring appears, and the parent drift contains limestone. With increase in the lime content, these soils grade imperceptibly into the Blue Lake soils and with increase in the clay content, into the Nester soils. They are essentially sandy in texture, strongly acid in the solum, and contain a low amount of limestone in the C horizon.

The Grayling soils are essentially sands, both in the solum and in the C horizon, yellow in color, low in moisture, strongly acid in the solum, and have a very small amount or no limestone in the parent drift. The gray and brown layers are weakly developed. The soils of the Grayling, Rubicon, Saugatuck, and Newton series constitute a moisture series differing in degree of development of the gray and brown layers, the amount of surface organic matter, and the degree of bleaching or leaching, but grading into each other imperceptibly. All are sands in texture, and all are low in lime or strongly acid. Maximum eluviation occurs in the gray layer and maximum cementation and thickness in the brown layer of the Saugatuck soils. The maximum accumulation of organic matter on the surface occurs in the Newton soils. In these soils the underlying sand is pale in color or bleached, due to water logging, and the brown layer, represented by pale-yellow or smoke-colored sand, is only feebly developed.

The Nester soils are heavy, very similar to the Isabella soils of southern Michigan, and might be regarded as a transitional or more strongly podsolized phase of those soils. With increase in the lime content, and especially in the content of limestone of gravel to stone size, the Nester soils grade into the Onaway soils which are widely distributed in the lake shore counties to the northwest and northeast and in the eastern half of the northern peninsula. The Emmet and Mancelona soils (not mapped in Crawford County), and the Blue Lake, Kalkaska, Roselawn, Grayling, and Rubicon soils constitute a series of sandy and gravelly soils, arranged according to the amount of limestone in the parent material and the degree of acidity, the

first containing the highest amount of limestone and the least total acidity. The difference between Blue Lake loamy sand and Roselawn sand is in the darker shade of color and higher percentage of colloids in the brown layer; the difference between the Kalkaska soils and the Grayling and Rubicon soils likewise lies mainly in the darker shade of color and greater loaminess of the brown layer of the former and also the greater accumulation of organic matter on the surface.

Coventry loam is peculiar in that it is characterized by a loam or sandy loam solum over coarse sand or sand and gravel at a depth ranging from 20 to 48 inches. Otherwise it is similar in profile and grades into Kalkaska sandy loam in some places and into Roselawn sandy loam in others. Typically the gray layer is ashlike and silty, and the brown layer is yellow or leather colored and not strongly developed.

The Bergland soils are underlain by a somewhat red limy clay substratum the same as, or similar to, that underlying the Nester soils, but the Bergland soils have developed under poor drainage. These soils are neutral or alkaline in reaction.

The Ogemaw soils have a thin covering of sand over clay and have developed under moderately poor drainage, but the Ottawa soils have a thicker covering of sand, and have developed under better drainage. The appearance of the profile of the Ogemaw sandy loam is similar to that of the Saugatuck soils, and the profile of the Ottawa soils is similar to that of the Rubicon and Roselawn soils.

The Griffin soils comprise recent stream alluvium, gray or light brown in color, with a variable amount of yellow or rust-colored spotting and streaking. The primary basis of differentiation is the high average moisture content, to the point of saturation at a slight depth. There is consequently a wide range in texture, in organic matter, and in mineral composition. Small areas of Echo soils have been included with the Griffin soils in mapping.

The organic soils, muck and peat, include five types or classes of material. Lupton muck includes the older, darker-colored, more decomposed, and loamy muck, which is generally nearly neutral in reaction and is underlain by deposits of peat more than 4 feet thick. Greenwood peat includes the raw, undecomposed, coarse-textured, yellow or brown, highly acid organic soil materials and in most places supports a heath-bog type of vegetation. Rifle peat occupies an intermediate position between Lupton muck and Greenwood peat in physical and chemical characteristics and depth of water table. Houghton muck includes brown, dark-brown, or black, coarse-textured, fibrous or stringy muck. Kerston muck is dark-colored muck or peat with which a considerable amount of stream alluvium is intermixed.

The study of the natural vegetation in relation to soil types [9] has a purely scientific interest as a part of soil science and ecology, and a significance in relation to problems of forestry and silviculture, and may have considerable value in determining the reconstruction of the original vegetal cover in detail. It has a direct application to agri-

[9] LIVINGSTON, B. E. THE RELATION OF SOILS TO NATURAL VEGETATION IN ROSCOMMON AND CRAWFORD COUNTIES, MICH. Mich. State Bd. Geol. Survey Rept. 1903: 9–30. 1905.

culture in a region like this, because the vegetation can be used as a criterion, within certain evident limitations, of the agricultural value of the land and its crop adaptation; and further, it has a bearing on the cost and methods to be followed for the reclamation of cut-over land, inasmuch as the kind of stumps on the land and the present growth are known or may be inferred. The relation of soils and natural vegetation in this county, based on observational and qualitative studies, are presented in Table 4.

TABLE 4.—*Correlation of soil types with natural vegetation in Crawford County, Mich.*

Soil type	Present (1927) growth (wild land)	Original growth
Roselawn sand	Dominantly small or sprout growth of scarlet, white, and red oaks, with aspen, red maple, and fire cherry less abundant; a few red (Norway) pine, fair size and dense cover of oaks where land is unburned; sweetfern (*Comptonia asplenifolia*), bracken, blueberries, briers, grasses, low willow, and sumac common.	Dominantly red pine; hardwoods and a small proportion of white pine on the soils characterized by sandy clay in the substratum; probably a few scattered oaks in the original cover.
Grayling sand	Predominantly jack pine and small scattered growth of oaks; trees widely spaced except for thickets of jack pine; bracken, sweetfern, blueberries, lichen, grasses, sedge, and low willow on more open land.	Red pine and jack pine; open land not densely forested except for jack pine thickets.
Nester loam	Second-growth hard maple (dominant), beech, elm, yellow birch, and white ash; aspen, witch-hazel, red maple, and grasses abundant in places.	Hardwood forest consisting principally of hard maple, beech, elm, ash, basswood, and hemlock, with a few white pine.
Rubicon sand	Oaks and aspen principally; jack pine, sweetfern, bracken, blueberries, willow, and wintergreen.	White pine and red pine, principal trees; probably a few hardwoods.
Roselawn sandy loam	Mainly fair-sized oaks, red maple, aspen, cherry, sumac, briers, grasses; open or moderately dense cover, depending on severity of fires.	Red pine, white pine numerous; hard maple, beech, elm, and hemlock on the heavier phases.
Ogemaw sandy loam	Aspen, alder, and willow forming a dense cover; second growth of original cover in places.	White pine abundant; variable quantity of elm, ash, beech, hemlock, basswood, aspen, spruce, fir, and arborvitae.
Coventry loam	Second-growth hard maple, chiefly; minor species, beech, hemlock, aspen, elm.	Dense cover of maple, beech, elm, hemlock, and a few scattered white pine.
Kalkaska sandy loam	Second growth of original species or dense growth of bluegrass, briers, with red maple sprouts, cherry, and aspen on the more severely burned-over land.	Dense forest of hard maple, birch, elm, hemlock, basswood, and a few scattered white pine.
Ottawa loamy sand	Red, white,and scarlet (pin) oaks, aspen, red maple, witch-hazel, bracken, sweetfern, spruce, fir, cedar, and hardwoods in places.	White pine (dominant) and red pine, fir, spruce, cedar, and swamp hardwoods in small bodies on benches along Au Sable River.
Saugatuck sand	Predominantly aspen and red maple; spruce, fir, and white cedar in the wetter places; dense cover of bracken, sweetfern, blueberries, and wintergreen.	White pine dominant; aspen, spruce, fir, white cedar, red maple, yellow birch, ash, and elm.
Bergland loam	Second-growth aspen, spruce, fir, white cedar, elm, ash, basswood, white birch, alder, willow, sedges, rush (Juncus), and cattails.	Mixed conifer and hardwood forest consisting of elm, ash, basswood, red maple, aspen, white pine, hemlock, spruce, and fir.
Newton loamy sand	Dense cover of alder, willow, and aspen; scattered original forest trees.	White pine, spruce, fir, and white cedar, with less white birch, red maple, hemlock, aspen, and yellow birch.
Bridgman fine sand	Small oaks and aspen; ground cover of bracken, sweetfern, blueberries, weeds, and grasses.	Red, jack, and white pines.
Blue Lake loamy sand	Small trees of original forest left in slashings, together with luxuriant growth of grasses (mainly bluegrass) and briers; open stump land comprises red maple sprouts, cherry, and aspen, together with briers and grasses.	Hard maple, beech, yellow birch, elm, hemlock, and scattered white pine.
Kalkaska loamy sand	Second-growth maple and elm chiefly; more severely burned-over land, aspen, fire cherry, red maple, a few scattered oaks; fairly heavy cover of grasses and briers.	Hard maple, beech, yellow birch, elm, hemlock, and white pine.

TABLE 4.—*Correlation of soil types with natural vegetation in Crawford County, Mich.*—Continued

Soil type	Present (1927) growth (wild land)	Original growth
Griffin sandy loam	Dense cover of elm, red maple, balm-of-Gilead poplar, ash, spruce, fir, cedar, aspen, alder, willow, and white birch.	In addition to species found at present, white pine, and hemlock in greater numbers.
Kerston muck	Spruce, fir, cedar, aspen, alder, willow, very small amount of elm, oak, balm-of-Gilead poplar, red maple; open land, in places grass meadow.	Probably much the same species as at present.
Rifle peat	Cut-over coniferous swamp; white cedar, black spruce, tamarack; dense alder, willow, sedge, grasses, leatherleaf, and various shrubs.	Dense growth of white cedar, black spruce, tamarack, and other plants as at present.
Lupton muck	Cut-over coniferous swamp; white cedar, spruce, fir, tamarack, balm-of-Gilead poplar, elm, and black ash.	Dense growth of white cedar, black spruce, tamarack, black ash, balm-of-Gilead poplar, elm, white pine, hemlock, and basswood.
Greenwood peat	Open heath bogs; leatherleaf, Labrador-tea, bog-rosemary (Andromeda), cranberry, Sphagnum moss, and sedges; dwarfed growth of scattered black spruce and tamarack.	Presumably the same as present growth.
Houghton muck	Sedges (*Carex* sp.) dominant, marsh grasses, flags, cattails, shrubby willow, aspen, and tamarack.	Probably same as present growth.

SUMMARY

Crawford County is in the north-central part of the southern peninsula of Michigan. It includes an area of 561 square miles, or 359,040 acres.

The surface features are of glacial origin and consist of level sandy plains, low hills and ridges, and plateaulike uplands characterized by long smooth slopes and broad shallow valleys. Lakes and swamps are features of the relief. The elevation above sea level ranges from about 1,100 to 1,400 feet.

It is estimated that about 87 per cent of the total area of the county is naturally well drained or dry, and that about 13 per cent is poorly drained or swampy.

The land was originally forested with hardwoods, and white and red (Norway) pines on the mineral soils and white cedar, spruce, fir, and tamarack in the peat swamps.

Agriculture and lumbering are the principal industries, and recreational attractions for hunters, fishermen, and tourists are also a considerable commercial asset.

Transportation facilities are afforded both by railways and by State trunk-line highways.

The main features of the climate are an average precipitation of about 30 inches annually, including snowfall; and a mean annual temperature of about 42° F. The winters are very cold and long and the summers short and mild. The growing season is short but is generally sufficient for the growth and maturity of potatoes, small grains, and hay.

Settlement of the county began about 1870. Farming, however, remained subordinate to lumbering while the virgin forests were being cut, and subsequently only a very small amount, less than 5 per cent of the cut-over land, was cleared for agricultural purposes. Much of the land is in forest reserves owned by the State, in reserves owned by hunting and fishing clubs, and in large tracts

owned by land and timber companies. The present farming consists mainly in the production of hay, oats, and potatoes, with dairying as an adjunct. Potatoes and milk are the chief sources of cash income. The amount of land in cultivation on individual farms is small, but farming is not intensive, and yields are low or only moderate. The selling price of land is comparatively low.

Twenty soil types and four phases of types, in addition to the organic soils, have been recognized and mapped in Crawford County. The greater parts of these soils are dry sands and sandy loams which range from low to medium in fertility. Practically none of the land is so rough or so excessively stony as to be nonarable, although the greater part is in small second-growth trees and stumps, and about 13 per cent is swampy or poorly drained.

The more productive and naturally more fertile soils, which are at present used for agriculture or have some immediate possibilities for agricultural use, are light loams and sandy loams classified as Coventry loam, Kalkaska sandy loam, Nester loam, and Roselawn sandy loam. These soils occupy moderately rolling hardwood upland. Kalkaska loamy sand is the most extensive soil on the hardwood plains. The more extensive soils on the pine plains are Grayling sand, Grayling coarse sand, and Rubicon sand. These soils are excessively dry and low in fertility. The sand on the pine and oak hills is mostly Roselawn sand, and on the hardwood hills Blue Lake loamy sand. Peat and muck soils comprise about 9 per cent of the total area of the county. Most of the peat deposits are more than 3 feet thick, coarse in texture, from moderately to strongly acid, and of very little or no agricultural worth at the present time. The peat areas are densely forested.

The well-drained soils having mature profiles belong to the podsol group of soils. Textural and chemical variations are closely related to the lithologic variations in, and forms of, the glaciai deposits which cover this region. The deposits, which are from 300 to 600 feet thick, comprise sands, clays, and gravel and are represented by moraines, till plains, and outwash plains. The deposits show the strongest influence from limestone and shale rock in the western part of the county. This influence decreases eastward and southward, and a corresponding general difference takes place in the soils. The mineral soils developed under swamp or wet conditions constitute about 4 per cent of the total area, and most of them are sandy in texture. Alluvial soils are not extensively represented as the land surface is comparatively young, and the few streams have not yet had time to develop wide flood plains. Water surface constitutes only about 1 per cent of the total area of the county. Most of the waters are alkaline in reaction, and the bottoms of lakes and streams are peat, marl, clay, and sand. Very little of the land is barren because of wind or water erosion, and no outcrops of indurated rocks or bedrock occur.

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[PUBLIC RESOLUTION—No. 9]

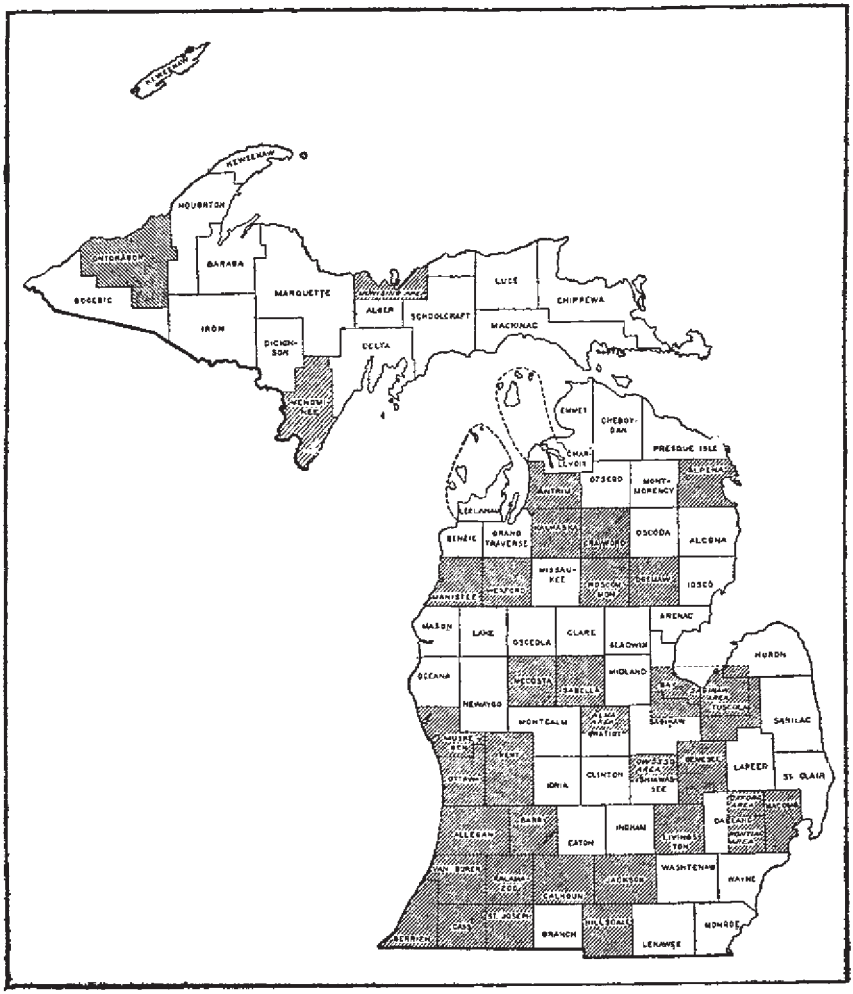
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Michigan, shown by shading

U. S. GOVERNMENT PRINTING OFFICE 1931

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HENRY G. KNIGHT, CHIEF
A. G. McCALL, CHIEF, SOIL INVESTIGATIONS
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
CRAWFORD COUNTY
MICHIGAN

MICHIGAN AGRICULTURAL EXPERIMENT STATION
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MICHIGAN DEPARTMENT OF CONSERVATION
G. R. HOGARTH, DIRECTOR

R. 4 W. R. 3 W. R. 2 W. R. 1 W.
T. 28 N. T. 27 N. T. 26 N. T. 25 N.
OTSEGO CO. CRAWFORD CO. KALKASKA CO. OSCODA CO. ROSCOMMON CO.

LEGEND

Bergland loam — Bl	Nester loam — Nl
Bergland clay loam — Bc	Newton loamy sand — Ns
Blue Lake loamy sand — Bk	Ogemaw sandy loam — Os
Bridgman fine sand — Bf	Ottawa loamy sand — Oy
Coventry loam — Cl	Roselawn sand — Rs
Grayling coarse sand — Gc	Rs Gravelly phase
Grayling sand — Gs	Roselawn gravelly sandy loam — Ro
Gs Gravelly phase	Roselawn sandy loam — Rl
Griffin sandy loam — Gm	Rubicon sand — Ru
Hartwick sand — Hs	Ru Gravelly phase
Kalkaska loamy sand — Kl	Saugatuck sand — Ss
Kl Gravelly phase	Houghton muck — Hm
Kalkaska sandy loam — Ks	Kerston muck — Km
Greenwood peat — Gp	Lupton muck — Lm
Rifle peat — Rp	

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort
Secondary roads and Trails
Railroads, Steam and Electric
Bridges, Ferry
R.R. crossings, Tunnel
Ford, Dam
School or Church, Cemeteries
Mine or Quarry, Mine dumps, Made land
Bluff, Escarpment, Rock outcrop, and Triangulation station
Stony and Gravelly areas
Soil boundaries
Boundary lines
Boundary lines
Boundary lines
U.S. township and section lines

RELIEF
(Printed in brown or black)

Contours, Depression contours
Prominent Hills, Mountain Peaks
Sand, Wash, and Sand dunes
Shore and Low-water line, Sandbar

DRAINAGE
(Printed in blue)

Streams
Lakes, Ponds, Intermittent lakes
Intermittent streams
Springs, Canals and Ditches, Flumes
Swamp, Salt marshes
Submerged marsh, Tidal flats

The above signs are in current use on the soil maps. Variations from the usage appear in some maps of earlier dates.

Mark Baldwin, Inspector, District 1.
Soils surveyed by J. O. Veatch, Michigan Agricultural Experiment Station, in charge, L. R. Schoenmann, Michigan Department of Conservation, Land Economic Survey, and Z. C. Foster and F. R. Lesh, U. S. Department of Agriculture.

Scale 1 inch = 1 mile
1 ½ 0 1 2 3 4 Miles

BASE MAP FROM
MICHIGAN DEPARTMENT OF CONSERVATION,
LAND-ECONOMIC SURVEY

WILLIAMS & HEINTZ CO., WASH., D.C.

Field Operations
Bureau of Chemistry and Soils
1927